The development and evaluation of a novel online tool for assessing dietary intake and physical activity levels for use in adult populations

HILLIER, FRANCES

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Frances Caroline Hillier

Abstract

The Synchronised Nutrition and Activity Program for Adults (SNAPA™) was developed to address the need for accurate, reliable, feasible, inexpensive and low burden methods for measuring diet and physical activity behaviours in free-living adult populations.

Usability testing (n=5) identified a number of usability issues and the program was revised accordingly. Test-retest reliability (n=44) revealed no substantial systematic shifts in mean values. Outcome variables were percentage food energy from fat (%fat), number of fruit and vegetable portions (FV), and minutes of moderate to vigorous activity (MVPA). Single measure intra-class correlations (ICC) ranged from 0.62 to 0.72 and average measure ICC range from 0.76 to 0.84.

The preliminary method comparison study (n=71) revealed correlations between SNAPA™ and multiple pass recall dietary interview-derived %fat and FV portions of 0.48 (bootstrapped 90% CI 0.31, 0.64) and 0.42 (bootstrapped 90% CI 0.22, 0.60) respectively. The correlation between SNAPA™ and accelerometry-derived MVPA was 0.39 (bootstrapped 90% CI 0.08, 0.64).

The in-depth primary method comparison study (n=77) investigated the agreement between SNAPA™ and dietary observation and combined heart rate and accelerometry. The mean match and phantom rates between SNAPA™ and lunchtime dietary observation was 81.7% and 5.6%, respectively. Correlations between SNAPA™ and the reference method outcomes ranged between 0.39 and 0.56. Passing-Bablok (type II) regression analysis revealed both fixed and proportional bias for the estimation of energy intake; proportional bias for fat intake (g); a fixed bias for MVPA, and no substantial biases for %fat or FV portions.

SNAPA™ was used to collect diet and physical activity data in a health promotion campaign, ‘Get a Better Life’ (n=1201), providing useful information on the feasibility of using the program in a real-world initiative.

SNAPA™ is a promising tool for the surveillance of diet and physical behaviours at a group level in adult populations.

THE DEVELOPMENT AND EVALUATION OF A NOVEL ONLINE TOOL FOR ASSESSING DIETARY INTAKE AND PHYSICAL ACTIVITY LEVELS FOR USE IN ADULT POPULATIONS

VOLUME 1 (of 2)

FRANCES CAROLINE HILLIER

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the degree of Doctor of Philosophy

School of Medicine and Health
Durham University

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Declaration

I confirm that the work in this thesis is my own and has not been submitted for any other degree at another university. I describe what I did below. Aspects of this research have been supported by others, as indicated.

Development of the Synchronised Nutrition and Physical Activity Program for Adults (SNAPA™)

The structure, content and questioning sequence of the Synchronised Nutrition and Physical Activity Program for Adults (SNAPA™) was planned and designed by me with the expert advice of my supervisors, Professor Carolyn Summerbell and Professor Alan Batterham. Advice was also sought from colleagues with backgrounds in nutrition, physical activity, psychology, sociology, and public health, including Dr Helen Moore and Dr Sally McLure who led the development of the similar programs for use in children. All computer programming was carried out by Mr Sean Crooks, with the assistance of Mr David Cumbor, from the School of Computing, Teesside University. I arranged consultations with the programmers before the work began to explain my ideas and I developed the questions, process flowcharts and notes that they used to inform the program development. During the development of SNAPA™, I met with the programmers at various time points to discuss and view progress and make any revisions required. I developed the underlying databases, SQL queries and Microsoft Excel file templates used to extract relevant data and calculate the outcome variables.

Usability testing

I developed the protocol, recruitment and all data collection materials, and wrote the ethics application with the guidance of my supervisors, and advice from an expert in human-computer interaction, Prof Paul van Schaik. I received training in the CAMTASIA from Ms Julie Blake, Research Assistant from the School of Social Sciences, Teesside University. I recruited and gained consent from all participants, carried out all study sessions, transcribed audio recordings and carried out all analysis.

Preliminary method comparison and test-retest reliability study

I developed the protocol, recruitment and all data collection materials, and wrote the ethics application with the guidance of my supervisors. I arranged all study sessions, which involved contacting local service centre managers. I received in-house training in accelerometry from Professor Alan Batterham. I was the primary contact for the recruitment of participants and was responsible for the preparation of the accelerometers before delivery to participants. I delivered and demonstrated the majority of the accelerometers, although I did receive some assistance from fellow colleagues in the Centre for Food, Physical Activity and Obesity. During the study sessions, I was assisted with the data collection (multiple pass recall dietary interviews and anthropometric measurements) and supervision of the completion of SNAPA™ by Ms Sarah Smith, Dr Helen Moore, Dr Nicola Heslehurst, Ms Claire O'Malley and Dr Sally McLure. Ms Sarah Smith assisted me with the data entry of dietary data into the nutritional software. I downloaded and processed the accelerometry data. The data analysis was carried out by me with the guidance of my supervisor Professor Alan Batterham.

Community Challenge Project (Get a Better Life campaign)

I was project manager, assisted with the protocol development and wrote the ethics applications along with supervisors (Principal Investigator and co-applicant) and the other co-applicants. I organised all steering group and team meetings. I led the development of the 'Get a Better Life' campaign in co-ordination with supervisors, co-applicants and staff from Gazette Media Group. I maintained and managed SNAPA™ with the assistance of Mr Sean Crooks. I was the primary contact for participants but was also assisted by other members of the project team: Ms Alisha Crayton (Research Assistant), Ms Catherine Nixon (Research Assistant) and Ms Claire Pedley (Research Associate). The arrangement of consultation and data collection sessions and the actual data collection was undertaken by me and the other team members: Ms Alisha Crayton, Ms Catherine Nixon and Ms Claire Pedley. I processed all of the data from SNAPA™ and carried out the data analysis under the guidance of Professor Alan Batterham.

Primary method comparison study

I developed the protocol, recruitment and all data collection materials, and wrote the ethics application with the guidance of my supervisors. I developed links with key contacts for access into workplaces. I met with all participants for a pre-participation screening and gaining consent. I carried out all physical activity monitor set-ups and calibration step-tests, with the assistance of either Dr Liane Azevedo (Teesside University), Ms Alisha Crayton or Ms Claire Pedley when groups were large. For the dietary observation I was assisted by fellow members of the Obesity Related Behaviours (ORB) research group: Ms Alisha Crayton, Mr Wayne Douthwaite, Ms France Thirlway, Dr Helen Moore, Ms Catherine Nixon, Ms Claire O'Malley and Ms Claire Pedley. I coded and entered all of the dietary observation data in the appropriate nutritional analysis software. I downloaded and processed all of the data from the physical activity monitors and SNAPA™. I analysed the data, using appropriate statistical tests, with the guidance of Professor Alan Batterham (supervisor) for all quantitative data and advice from Ms Catherine Nixon for the qualitative data.

Statement of Copyright

Acknowledgements

I wish to thank my supervisors Prof Carolyn Summerbell and Prof Alan Batterham for their invaluable input, advice, support and encouragement given to me throughout this PhD and all my time working at Durham and Teesside Universities.

I express my gratitude to Sean Crooks and David Cumbor for all of their work in bringing SNAPA™ 'to life' and keeping it maintained throughout the various stages of this work.

Thank you to my colleagues and fellow PhD students at Durham and Teesside Universities for their assistance with data collecting when needed, as well as their friendship over the years. Special thanks go to Sarah Smith for her help in the preliminary evaluation work, especially for the assistance with the data input, and fellow 'Get a Better Life' team members, Alisha Crayton, Catherine Nixon and Claire Pedley, for all of their hard work on the Community Challenge Project.

Grateful thanks go to Scott Lloyd from NHS Stockton for his kind advice and assistance with contacting the various workplaces in Teesside for the final evaluation work. Thank you also to staff at the Evening Gazette for their input and enthusiasm when developing the 'Get a Better Life' campaign.

I wish to thank all of my many participants, whom meeting really helped make this experience such an enjoyable one. I wish them all the best for the future.

Finally, thank you to my mum for her help painstakingly proof reading this thesis; and, to Mum, Dad and Ross, thank you for your continuous support, understanding and belief for which I am always truly grateful.

Dissemination of work

Submitted to Peer Review Journals

Hillier FC, Batterham AM, Summerbell CD
Validation of a novel internet-based computer program to assess previous day dietary and physical activity behaviours in adults: The Synchronised Nutrition and Activity Program for Adults (SNAPA™)
Submitted to British Journal of Nutrition, November 2010, under review

Nixon CA, **Hillier FC**, Crayton AM, Pedley CL, Summerbell CD.
The impact of 'pledge-making' and perceived social support for participants making and maintaining healthful behaviour changes: A theoretical thematic analysis
Submitted to Qualitative Health Research, October 2010, under review

Moore HJ, **Hillier FC**, Batterham AM, Ells LJ, Summerbell CD.
Technology Based Dietary Assessment: Development of the Synchronised Nutrition and Activity Program (SNAP™)
Submitted to Journal of Human Nutrition and Dietetics for supplement issue on technology assisted dietary assessment

Conference proceedings

Hillier, F.C., Batterham, A.M., Crooks, S. and Summerbell, C.D. (2008) Concurrent validity of a novel online tool for public health surveillance of dietary and physical activity behaviours in adults. *International Journal of Obesity, 16th European Congress on Obesity (ECO) Conference Proceedings;* **32** (S1): p32, T5 OS2.3 *(appendix p1)*

Hillier, F.C., Batterham, A.M., Crooks, S. and Summerbell, C.D. (2008) A novel online tool for capturing dietary and physical activity behaviours in adults: concurrent validity against standard reference methods. *Proceedings of the Nutrition Society, 2008 Summer Conference;* **67** (OCE8): E370 *(appendix p2)*

Hillier, F.C., Batterham, A.M., Pedley, C.L., Crayton, A.M., Nixon, C.A., Crooks, S. and Summerbell, C.D. (2009) Diet and physical activity behaviours assessed by a novel online data collection tool in the "Get a Better Life" study. *Obesity Facts, 17th European Congress on Obesity (ECO) Conference Proceedings;* **2** (S2): p68, T1 PO.56 *(appendix p3)*

Hillier, F.C., Batterham, A.M., Pedley, C.L., Crayton, A.M., Nixon, C.A. and Summerbell, C.D. (2009) Online vs face-to-face recruitment of participants in the Get a Better Life study: a social marketing campaign to encourage healthy eating and increase physical activity levels in adults. *2009 Annual Conference of the International Society of Behavioural Nutrition and Physical Activity;* p273, P1 T4.20 *(appendix p4)*

Hillier, F.C., Batterham, A.M. and Summerbell, C.D. (2010) Objectively-measured physical activity in adults in North East England: Prevalence depends critically on measurement method. *2010 Annual Conference of the International Society of Behavioural Nutrition and Physical Activity;* p288, P038 *(appendix p5)*

Hillier, F.C., Batterham, A.M. and Summerbell, C.D. (2010) The Synchronised Nutrition and Activity Program for Adults (SNAPA™): Accuracy against direct diet observation and synchronised heart rate and accelerometry. *Obesity Reviews, 11th International Congress on Obesity (ICO) Conference Proceedings*; **11** (S1); p400, T4:PO.334 *(appendix p6)*

Presentations

'Concurrent validity of a novel online tool for public health surveillance of dietary and physical activity behaviours in adults.'
16th European Congress on Obesity (ECO), May 2008
Palexpo Exhibition and Congress Centre, Geneva, Switzerland
Oral presentation

'The Get a Better Life campaign: Techniques in motivating healthy lifestyle change'
Higher Educational Business Partnership Annual HE in FE Conference, June 2008
Clarendon Building, Teesside University
Invited speaker

'A novel online tool for capturing dietary and physical activity behaviours in adults: concurrent validity against standard reference methods'
Nutrition Society Summer Meeting, June 2008
Maths and Physics Building, University of Nottingham
Oral presentation

'The Synchronised Nutrition and Activity Program for Adults'
Lunchtime seminar series, October 2008
Human Nutrition Research Centre, Newcastle University
Invited speaker

'Get a Better Life: A social marketing campaign to encourage healthy eating and increase physical activity in adults living in the Tees Valley'
CELS Health and Well-being Surgery, March 2009
St James' Park, Newcastle
Invited speaker

‘Physical Activity Behaviours of Adults in the Community Challenge Project’

North East Obesity Forum: ‘Can you be fit and fat’, November 2009

Beehive Research Suite, Newcastle University

Invited speaker

‘The Synchronised Nutrition and Activity Program for Adults’

ESF Exploratory Workshop on ‘Exploring New Directions for the Assessment of Dietary Intake and Physical Activity’, November 2009

Lindesfarne Centre, Durham University

Workshop co-ordinator and speaker

‘The development and evaluation of a novel online tool for assessing dietary intake and physical activity levels for use in adult populations’

School for Medicine and Health Postgraduate Research Annual Conference, June 2010

Ebsworth Building, Durham University, Queen’s Campus

Speaker

Professional Development

North East GRAD School
Durham University, July 2010
Participant

Emergency First Aid at Work
Durham University, March 2010
Participant

MSc Module: Public policy, Health and Health Inequalities
Durham University, January to March 2010
Participant

Workshop on the use of Technology in Dietary Assessment of Children: Current Applications, Problems and Solutions
Newcastle University, December 2009
Invited participant

ESF Exploratory Workshop on 'Exploring New Directions for the Assessment of Dietary Intake and Physical Activity'
Durham University, November 2009
Workshop co-ordinator and speaker

Writing for Publication
Durham University, October 2009
Participant

International Society for the Advancement of Kinanthropometry (ISAK) Training Course
Robert Gordon University, Aberdeen, June 2008
Participant: accreditation as Level One Anthropometrist

PHSRN Workshop: Assessing the Diet at the Ends of Life's Spectrum

MRC Human Nutrition Research, Cambridge, Dec 2007

Participant

The 2nd Cambridge Physical Activity Measurement Seminar

MRC Epidemiology Unit, Cambridge, Sep 2007

Participant

Chapter One: Introduction

1.1. Diet, Physical Activity and Health

Poor diet and low levels of physical activity are associated with a number of chronic diseases and conditions. Of these, the chronic diseases and conditions that are of particular public health importance in the UK are summarised in table 1.1.

Table 1.1 The major chronic diseases and conditions of public health importance in the UK

Chronic disease/risk factor	Public health impact
Cardiovascular disease (includes coronary heart disease and stroke)	Greatest cause of mortality and morbidity in England Accounts for 39% of all deaths in men and women per year
Non-insulin dependent diabetes mellitus	Accounts for approximately 9% of the annual NHS budget (approximately £5.2 billion per year) Associated with other conditions such as kidney disorders, retina damage and coronary heart disease
Cancer	Over 220,000 people are diagnosed and over 120,000 die from cancer each year More than 1 in 3 people will develop cancer during their lifetime
Obesity	24% of men and 25% of women are obese, and 66% of men and 57% of women are overweight including obese Associated costs are estimated to reach £50 billion per year by 2050 on current trends Obesity doubles the risk of all-cause mortality, coronary heart disease, stroke and type 2 diabetes, and increases the risk of some cancers

1.1.1. Diet and health

It is well accepted that a balanced diet, high in fruits, vegetables and non-refined (wholegrain) carbohydrates, has many health benefits through the provision of essential nutrients and bioactive compounds. In 2002, the World Health Organisation estimated that 2.7 million (4.9%) deaths per year are due to low fruit and vegetable intake (World Health Organisation, 2002). However, it is sometimes difficult to evidence associations between diet and disease because of the complexity of diets and nutrient-interactions, and limitations in the methods used to assess diet (Bingham *et al.*, 2003b).

Diet is associated with chronic diseases such as cardiovascular disease, diabetes and cancer. Dietary fats, in particular saturated and trans fats, are linked with increased risk of cardiovascular disease (mainly coronary heart disease) (Hu *et al.*, 1997; Oh *et al.*, 2005) through adverse effects on blood cholesterol (Ascherio *et al.*, 1996). However, a recent meta-analysis of prospective epidemiologic studies showed no significant evidence that dietary saturated fat is associated with an increased risk of coronary heart disease or cardiovascular disease (Siri-Tarino *et al.*, 2010a). It is possible that unstudied risk factors may also be associated with the relationship between dietary fat and cardiovascular disease. For example, the benefit of reducing saturated fat may be compromised if intake is replaced by refined carbohydrate (Siri-Tarino *et al.*, 2010b), demonstrating the complexity of diet and nutrition interactions. Wholegrain, fruit and vegetable and fish consumption have been shown to decrease the risk of cardiovascular disease (Bingham *et al.*, 2008; Dauchet *et al.*, 2006; Flight and Clifton, 2006; Iso *et al.*, 2001; Jensen *et al.*, 2004; Liu *et al.*, 1999; Liu *et al.*, 2000; Steffen *et al.*, 2003a).

It has been estimated that diet is responsible for 10 to 30% of cancers in developed countries (Peto, 2001). There is currently no convincing evidence to link specific foods to increased or decreased risks of developing the disease (World Cancer Research Fund/American Institute for Cancer Research, 2007). However, fibre, fruit and vegetables, and fish have been linked to decreased risks in site-specific cancers (Bingham *et al.*, 2003a; González *et al.*, 2006b; Hall *et al.*, 2008; Jacobs *et al.*, 1998; Miller *et al.*, 2004; Peters *et al.*, 2003; van't Veer *et al.*, 2000), and high intakes of red and processed meat, saturated fat and salt have been linked to increased risks (Bingham *et al.*, 2003b; González *et al.*, 2006a; Larsson *et al.*, 2006a; Larsson *et al.*, 2006b; Larsson and Wolk, 2006; Sandhu *et al.*, 2001; Shikata *et al.*, 2006; Thiébaut *et al.*, 2007).

There is some evidence to suggest that decreased risk of developing non-insulin dependent diabetes mellitus is associated with wholegrain and green leafy vegetable intake (Carter *et al.*, 2010; de Munter *et al.*, 2007; Venn and Mann, 2004). However, the evidence linking diet and prevention of non-insulin dependent diabetes mellitus is weak in general (Carter *et al.*, 2010; Nield *et al.*, 2008; Priebe *et al.*, 2008), although there is strong evidence that weight gain and obesity are associated with non-insulin dependent diabetes mellitus (Kopelman, 2007).

1.1.2. Physical activity and health

The associations between physical activity and fitness and health in adults are well established. It is estimated that, globally, physical inactivity causes 1.9 million deaths per year (World Health Organisation, 2002). In England the cost of physical inactivity is an estimated £8.2 billion a year, which includes the direct costs for treatment of the related diseases, and the indirect costs associated with sickness absence (Department of Culture Media and Sports, 2002).

Physical inactivity is a major risk factor for a number of chronic diseases as well as all-cause mortality (Department of Health, 2004; Livingstone *et al.*, 2003; USA Department of Health and Human Services, 1996). In 2002, the World Health Organisation estimated that physical inactivity was responsible for about 10–16% of cases of breast cancer, colon and rectal cancers and non-insulin dependent diabetes mellitus, and 22% of coronary heart disease, globally (World Health Organisation, 2002).

The relationship between physical activity and coronary heart disease is well established (Kohl, 2001; Thompson *et al.*, 2003). Lifestyle activities that meet moderate intensity, such as walking, gardening and regular stair climbing have been associated with lower incidence of coronary heart disease and risk factors including low HDL-cholesterol (Boreham *et al.*, 2000; Hardman and Hudson, 1994; Kelley *et al.*, 2004; Sesso *et al.*, 2000; Vuori *et al.*, 1994). There are less data available on the relationship between physical activity and stroke, but that which is available suggests that moderate to vigorous physical activity reduces the risk of stroke (Lee *et al.*, 2003).

Physical inactivity is associated with an increased risk of non-insulin dependent diabetes mellitus (Ivy *et al.*, 1999), and moderate physical activity is associated with decreased risks (Hu *et al.*, 1999; Lynch *et al.*, 1996; Manson *et al.*, 1992). Lifestyle changes in diet and physical activity have been shown to delay the development of non-insulin dependent diabetes mellitus in people with impaired glucose intolerance (Diabetes Prevention Program Research Group, 2002; Pan *et al.*, 1997; Tuomilehto *et al.*, 2001), and in one study to be more effective than the drug metformin (Diabetes Prevention Program Research Group, 2002).

Physical inactivity is also associated with adverse musculoskeletal health, such as osteoporosis and lower back pain (Department of Health, 2004). The burden of osteoporosis costs approximately £1.7-1.8 billion per year in the UK, and with around 60,000 cases each year, hip fractures account for 85-95% of the total costs (Burge *et al.*, 2001). Lower back pain is a common problem in the UK, and responsible for an estimated 150 million days a year lost from work (Clinical Standards Advisory Group, 1994).

Mental illness, such as anxiety and depression, is a major concern, with one in six people suffering from a mental health problem at any one time in the UK (Singleton *et al.*, 2001). In England, treatment of mental illness costs the NHS approximately £3.8 billion per year (Department of Health, 2003). Physical activity is associated with decreased risk of depression (Camacho *et al.*, 1991; Farmer *et al.*, 1988; Paffenbarger *et al.*, 1994; Strawbridge *et al.*, 2002). Physical activity is also useful for the treatment of mental illness (Craft and Landers, 1998; Lawlor and Hopker, 2001).

1.1.3. Overweight and obesity

In recent years, the predominate interest in dietary and physical activity behaviours has been in relation to obesity, one of the most important public health concerns in the developed world. Obesity is associated with increased risk of developing the metabolic syndrome (the clustering of risk factors including hypertension, elevated plasma insulin concentrations and insulin resistance, hyperglycemia and hyperlipidemia), type 2 diabetes, hypertension, cardiovascular disease, respiratory problems, cancers, infertility, osteoarthritis and liver and gall bladder disease (Kopelman, 2007).

In simplistic terms obesity is caused by an energy imbalance, where energy taken in (diet) exceeds energy expended (physical activity) over a sustained period of time. However, the causes of this imbalance are extremely complex involving genetic, physiological, psychological and social factors as well as interactions between these factors (Butland *et al.*, 2007). Humans are especially prone to obesity due to inherent survival mechanisms that were needed in times of food scarcity. Unfortunately in current times the food supply is plentiful for most people living in developed countires, and these mechanisms lead to weight gain unless overridden by conscious control.

1.1.4. Government targets and recommendations

Dietary recommendations

Current dietary recommendations are based on reports of the Committee on Medical Aspects of Food Policy (COMA) (Department of Health, 1991; Department of Health, 1994; Department of Health, 1998) and are summarised in table 1.2. For fruit and vegetables, one portion weighs 80 grams; therefore the recommended value represents five portions per day. The ‘five a day’ initiative has been promoted in the UK since 2003 and is probably one of the most well known public heath messages.

Table 1.2 Dietary recommendations for adults in the UK, in terms of percentage of total energy (percentage food energy) unless otherwise stated (Department of Health, 1991; Department of Health, 1994; Department of Health, 1998)

Nutrient			**Recommended value**
Total fat			33% (35%)
	Saturated fatty acids		10% (11%)
	Cis-polyunsaturated fatty acids		6 (6.5) to 10%
		n-6	>0.2%
		n-3	>1.0%
	Cis-monounsaturated fatty acids		12% (13%)
	Trans fatty acids		2% (2%)
Carbohydrates			47% (50%)
	Non-milk extrinsic sugars (free sugars)		0 to 10% (11%)
Protein			10 to 15%
Fruit and vegetables (g/day)			≥400
Dietary fibre (g/day)			≥18
Salt (g/day)			<6

Physical activity recommendations

The Department of Health physical activity recommendations are as follows (Department of Health, 2004):

- For general health benefit, adults should achieve a total of at least 30 minutes a day of at least moderate intensity physical activity on 5 or more days of the week.
- The recommended levels of activity can be achieved either by doing all the daily activity in one session, or through several shorter bouts of activity of 10 minutes or more. The activity can be lifestyle activity or structured exercise or sport, or a combination of these.
- It is likely that for many people, 45-60 minutes of moderate intensity physical activity a day is necessary to prevent obesity.
- For bone health, activities that produce high physical stresses on the bones are necessary.

In addition to the individual based recommendations, further government reports set out population wide targets for physical activity. The 'Game Plan' report (Department of Culture Media and Sports, 2002) proposed that by 2020, 70% of adults should be undertaking 30 minutes of moderate to vigorous physical activity on at least 5 days a week; and as an interim target, 50% of individuals undertaking 30 minutes of moderate to vigorous physical activity on at least five days a week by 2011. The Department of Health 'Be active, be healthy: A plan for getting the nation moving' aimed to lift one million people out of inactivity by reducing the proportion of the population achieving 30 minutes of continuous moderate to vigorous physical activity on less than one day per week; help 200,000 more people to realise the general health benefits of achieving 30 minutes of moderate to vigorous physical activity on five or more days per week; and increase the average weekly duration of physical activity by approximately 5% over the baseline (Department of Health, 2009).

These targets are mainly aimed at increasing physical activity levels of those who are currently inactive as, from a public health perspective, the largest reduction in risk of chronic disease will be achieved if inactive individuals move to low to moderately active levels (Department of Health, 2004).

Improving diet and increasing physical activity are also central to the 'Healthy Weight, Healthy Lives' cross-government strategy for England (Cross-Government Obesity Unit *et al.*, 2008). The target set by this strategy is to *'be the first major nation to reverse the rising tide of obesity and overweight in the population'* (Cross-Government Obesity Unit *et al.*, 2008).

1.1.5. Current dietary intakes and physical activity levels in the UK

Dietary intakes

Current dietary intakes are derived from the most recent National Diet and Nutrition Survey (NDNS) for adults (aged 19 to 64 years), which was carried out between July 2000 and June 2001 (Henderson *et al.*, 2002; Henderson *et al.*, 2003). The mean intakes of energy, fat and fruit and vegetables from this survey are displayed in table 1.3.

Table 1.3 Current mean dietary intakes of adults in the UK (Henderson *et al.*, 2002; Henderson *et al.*, 2003)

Nutrient	Men (n=833)	Women (n=891)
Energy, MJ (kcal)	9.72 (2313)	6.87 (1632)
Total fat, g	86.5	61.4
Percentage food energy from fat	35.8	34.9
Saturated fat, g	32.5	23.3
Percentage food energy from saturated fat	13.4	13.2
Portions fruit and vegetables	2.7	2.8

More recently, the Low Income Nutrition and Diet Survey was carried out between November 2003 and January 2005, in households that fell within approximately the bottom 15% of the population in terms of material deprivation (Nelson *et al.*, 2007). Results in terms of fat and fruit and vegetable intake were similar to the NDNS findings. Mean daily intake of total fat was 79.1g for men and 59.4g for women, with percentages of food energy from total fat of 35.9% and 35.2% respectively. Saturated fat intakes were 30.4g for men and 23.4g for women, with percentages of food energy from saturated fat of 13.7 for both. Average fruit and vegetable portions eaten per day were 2.4 for men and 2.5 for women.

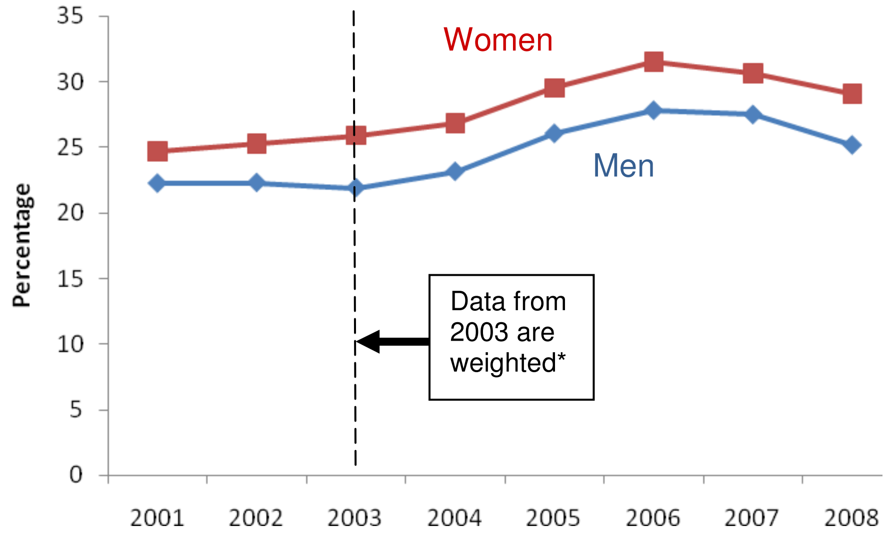
Results from both the NDNS and Low Income Diet and Nutrition Survey indicate that on average, population levels of saturated fat are higher than the recommended amount and fruit and vegetable consumption is lower than recommended. Total fat intake, however, is approximately at the recommended level.

Data on fruit and vegetable consumption are also collected as part of the Health Survey for England. Figure 1.1a shows the proportion of adults meeting the ‘five a day’ recommendation from 2001. Overall, a higher proportion of women meet the recommendation. However, the prevalence rates have followed a similar pattern for both men and women, with increases in prevalence from 2001 to 2006, followed by decreases in 2007 and 2008. Longitudinal data on energy intake from the Family Food survey, a component of the Living Costs and Food Survey run by the Office for National Statistics, and sponsored by the Department for

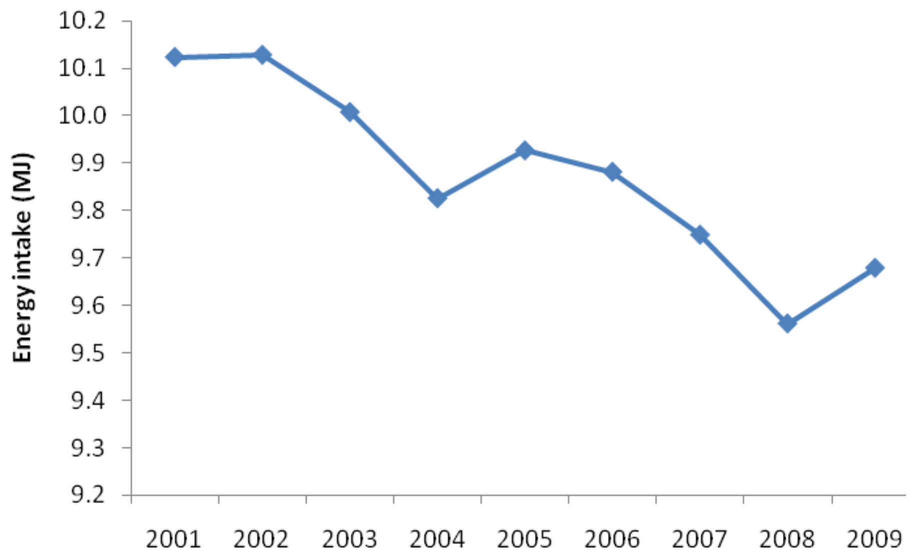
Environment, Food and Rural Affairs are presented in figure 1.1b and show that mean daily energy intake, although increased from 2008 to 2009, has followed an overall downward trend since 2001 (Department for Environment, Food and Rural Affairs, 2010).

Figure 1.1 a) Prevalence of adults consuming five or more portions of fruits and vegetables in England by gender, 2001 to 2008 (NHS Information Centre, 2009) **b)** Mean daily energy intakes of adults in the UK, 2001 to 2009 (Department for Environment, Food and Rural Affairs, 2010)

a)



b)



**From 2003, calibration weighting was used to reduce non-response bias resulting from differential non-response at the household level, based on the age and sex profile of the residents and the region in which the household was situated.*

Physical activity levels

In the 2008 Health Survey for England physical activity were measured both by self-report (interview) and, for the first time, objectively (accelerometry) in a subsample of households. Based on self-reported data, 39% of men and 29% of women met the Department of Health 'at least five times a week' recommendation. The number of people meeting the recommendations appears to be higher in younger age groups (figure 1.2). Self-reported moderate to vigorous physical activity per day, carried out in bouts of 10 minutes or more, was on average 73 minutes for men and 50 minutes for women. However, when this activity was assessed using accelerometry, only 6% of men and 4% of women met the recommendations and, again, a greater proportion of younger people met the recommendations (figure 1.3). Accelerometer determined average minutes of moderate to vigorous physical activity per day, carried out in bouts of 10 minutes or more, was 11 minutes for men and 8 minutes for women.

Trend data based on self-reported activities levels suggest that physical activity levels are increasing in both men and women with steady increases in the percentage meeting the physical activity recommendations from 1997 (figure 1.4). Despite this increase, at current rates it seems unlikely that the 'Game Plan' target of 50% of individuals meeting the recommended physical activity levels by 2011 will be achieved. If trends continue at rates displayed in figure 1.4, an approximately estimated 32% of women and 48% of men will meet the recommended target.

Figure 1.2 Current self-reported physical activity levels in England in 2008; men n=7305, women n=7660 (Craig *et al.*, 2009)

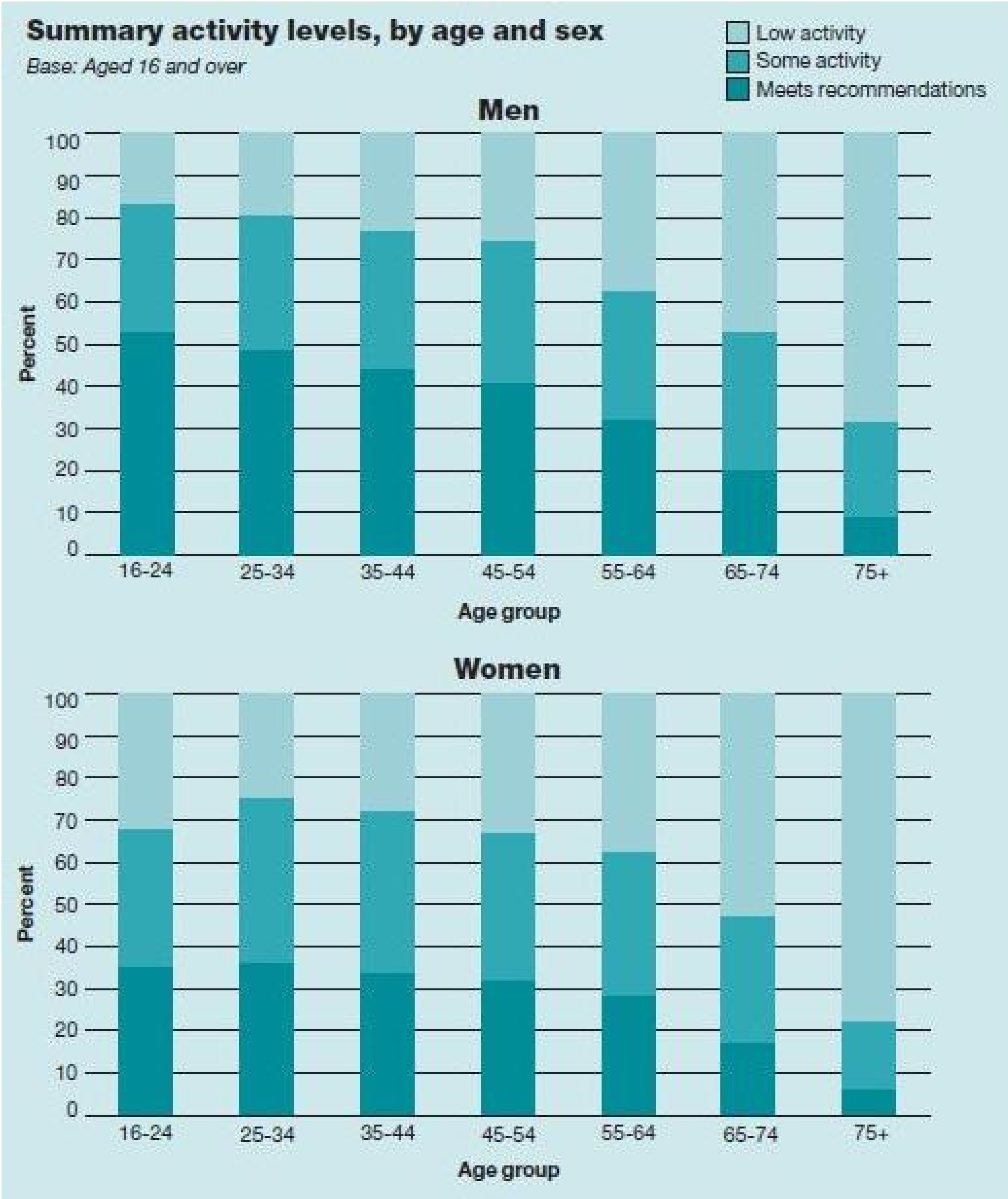


Figure 1.3 Current accelerometer determined physical activity levels in England in 2008; men n=610, women n=586 (Craig *et al.*, 2009)

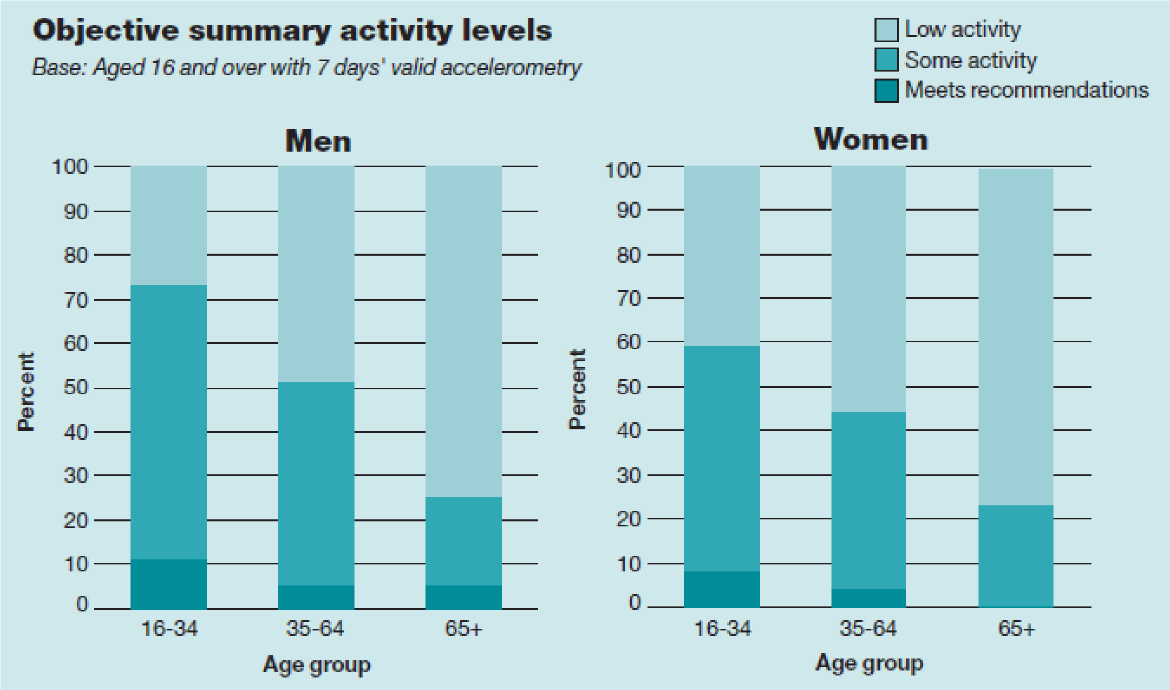
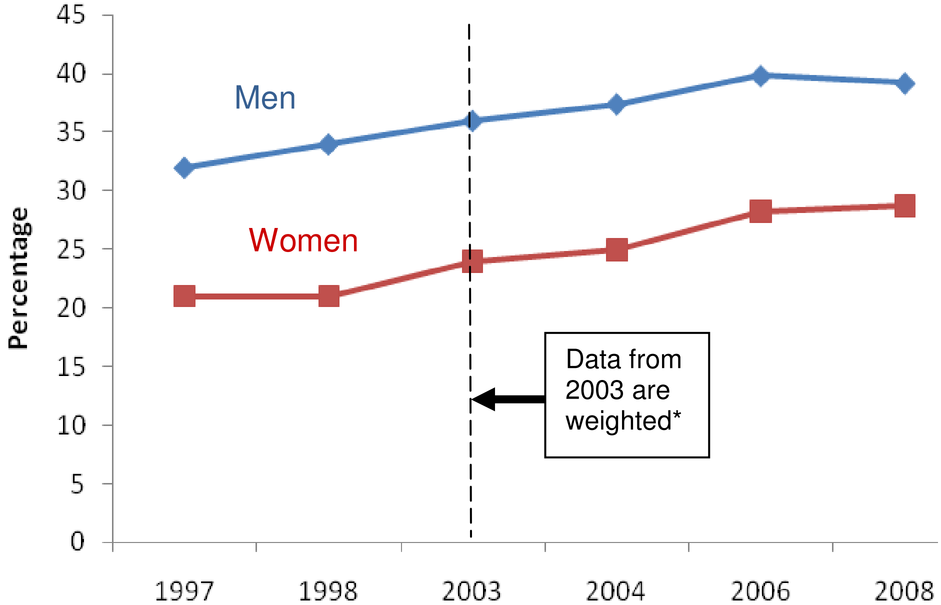


Figure 1.4 Prevalence of adults meeting physical activity recommendations in England by gender, 1997 to 2008 (NHS Information Centre, 2009)

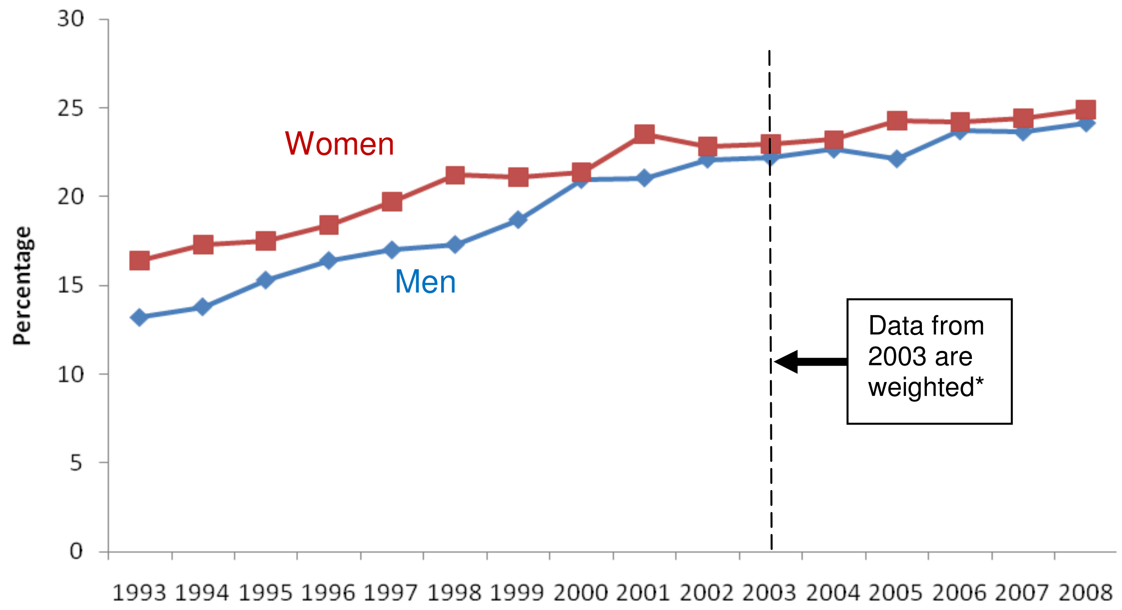


**From 2003, calibration weighting was used to reduce non-response bias resulting from differential non-response at the household level, based on the age and sex profile of the residents and the region in which the household was situated.*

Obesity prevalence

Obesity data are collected through the Health Survey for England using body mass index (BMI; kg/m^2). Since 1993 there has been a steady increase in the percentage of adults who are categorised as obese (BMI of 30 or above) in both men and women (figure 1.5).

Figure 1.5 Prevalence of obesity in adults in England by gender, 1993 to 2008 (NHS Information Centre, 2009)



**From 2003, calibration weighting was used to reduce non-response bias resulting from differential non-response at the household level, based on the age and sex profile of the residents and the region in which the household was situated.*

1.2. Importance of diet and physical activity measurement

In order to identify and monitor a problem and/or related factors, and then detect changes over time, either naturally occurring or in relation to an intervention; measurement of the problem and/or related factors is required. In short, if you can not count it, you can not control it. Therefore, the measurement of diet and physical activity is important for three main purposes:

- Collecting longitudinal data for the understanding of how the physical activity and dietary intake patterns over the lifespan may have an impact on health and functional status in later years and old age
- The surveillance of population diet and physical activity levels in relation to government recommendations and targets
- Evaluation of interventions targeted at improving diet and physical activity behaviours

As discussed in the previous section, improving diets and increasing physical activity levels are major public health priorities in the UK for the reduction of mortality and morbidity caused by chronic diseases such as cardiovascular disease, diabetes and cancer, primarily through halting and reversing the current trend of rising obesity rates. A number of policies, interventions and initiatives, big and small, targeting these behaviours have been implemented throughout the UK. Ongoing evaluation of such interventions for continuous improvement is identified as a core principle of tackling obesity in the Foresight Tackling Obesities: Future Choices report (Butland *et al.*, 2007).

Assessment methods need to be accurate, reliable, robust and suitable for use by representative samples of the population. Imprecise methods may lead to important links between behavioural variables and health being undetected (Bingham *et al.*, 2003b). Therefore it is important to understand the reliability (extent to which it measures the same thing each time) and validity (extent to which it reflects the 'truth' of what it is measuring) of assessment methods. The importance of using validated methods has been highlighted in the National Obesity Observatory Standard Evaluation Framework for weight management interventions (Roberts *et al.*, 2009). Worryingly, some local and national data have been, and continues to be, gathered using instruments with unknown reliability and validity (Roberts, 2010).

1.3. Brief overview of current diet and physical activity assessment methods

In this section I will give an overview of the dietary and physical activity assessment methods currently available for use, with a particular focus on the issues surrounding the methods that have been used in the evaluation phases of this PhD thesis. A summary of the strengths and weaknesses of each method are displayed at the end of each sub-section in tables 1.5 & 1.6. There are many challenges and sources of error associated with physical activity and dietary assessment, some unique to the particular behaviour, but many are common in both behaviours. The main challenges will be discussed at the end of this section.

1.3.1. Dietary assessment methods

Methods of dietary assessment can be grouped into the following categories:

- Biomarkers
- Observation
- Self-report

The most extensively used group are the self-reported methods, which consist of a number of techniques that can be divided in to concurrent (real-time) and retrospective methods. A summary of the advantages and disadvantages of each method is provided in table 1.5.

1.3.1.1. Biomarkers

Doubly labelled water

The doubly labelled water method is described in the physical activity assessment section of this chapter as it is a measurement of total energy expenditure. The doubly labelled water method provides the most accurate measurement of total energy expenditure and is therefore considered to be a ‘criterion’ method. Theoretically the measure of total energy expenditure can be used as a measure of energy intake, however this can only be assumed to be true in weight stable individuals (i.e. individuals who are not growing, losing weight, pregnant or ill).

The main weakness of using doubly labelled water is that it only provides a measure of total energy intake and not sub-domains of diet, for example fruit and vegetable, fat and carbohydrate intake. The doubly labelled method is also limited in the assessment of individuals on weight reduction diets, where energy intake will be less than energy expenditure. Doubly labelled water is also extremely expensive, which restricts its use to small samples. Therefore doubly labelled water is mainly used as a validation method on which to compare methods of dietary assessment using self reported energy intake. The doubly labelled water method is unable to validate dietary assessment methods in terms of sub-domains of diet.

Other biomarkers

Naturally occurring biomarkers, obtained from biological specimens such as blood, urine or hair, have the potential to provide objective indices of dietary intake. Dietary biomarkers may be a biochemical indicator of dietary intake or nutritional status; an index of nutrient metabolism; or a marker of biological consequences of dietary intake (Potischman and Freudenheim, 2003).

There are four categories of dietary biomarkers: Recovery, predictive, concentration and replacement (Jenab *et al.*, 2009). Recovery biomarkers use the concept of metabolic balance between intake and excretion over a fixed period of time, i.e. excretion is highly correlated with intake, and provides an estimate of absolute intake values (Kaaks *et al.*, 1997). Doubly labelled water is an example of a recovery dietary marker, along with urinary nitrogen and potassium, for the measurement of protein and potassium intake, respectively. Predictive biomarkers are similar to recovery biomarkers, in that excretion levels are related to intake levels over a fixed time period. There is a lower overall recovery of excreted levels, which show a dose-response relationship with intake levels. This category of dietary biomarker is relatively new and the only current examples reported in the literature are urinary sucrose and fructose for the measurement of sugar intake (Tasevska *et al.*, 2005).

Concentration biomarkers, as the name suggests, use the concept that the concentration of a biomarker in a biological sample (e.g. serum, blood, urine) is correlated with intakes of corresponding foods or nutrients (although cannot determine absolute amounts) (Jenab *et al.*, 2009). Examples of concentration biomarkers include serum vitamins as indicator of fruit and vegetable intake; and blood lipids as indicators of fat intake and possibly dietary fibre (Bingham *et al.*, 2008). Replacement biomarkers are similar to concentration biomarkers but are used for nutrients or compounds with unsatisfactory or unavailable food composition data, for example aflatoxins, phytoestrogens and salt (Jenab *et al.*, 2009).

Biomarkers are extremely useful for the validation and calibration of subjective dietary assessment methods (Kohlmeier, 1995). However, the relationship between the biomarker and the dietary intake component needs to be well established through calibration studies in metabolic chambers (Bingham, 2002). To date, this has only been established in a few biomarkers (Bingham, 2002). Daily urinary nitrogen shows a good relationship with daily nitrogen intake in individuals whose diets have remained constant over a prolonged period of time (Bingham, 2002). Studies have shown that urinary nitrogen accounts for approximately 80% of dietary nitrogen (Bingham and Cummings, 1985; Kipnis *et al.*, 2001). When using this method nitrogen balance in subjects is assumed (accumulation can occur as a result of growth or repair of muscle tissue, loss as a result of starvation, slimming or injury); sufficient samples need to be collected; and completeness of the samples can be determined using *p*-aminobenzoic acid (PABA) (Jakobsen *et al.*, 2003).

A weakness associated with dietary biomarkers is that specialised facilities and expertise are required to process, store and analyse samples. Biomarkers are also limited in the number of foods or nutrients that can be assessed and a number of factors may influence relationships between dietary biomarkers and nutrients. These include genetic and metabolic factors as well as processes used in the collection and analysis of biological samples (table 1.4).

Table 1.4 Factors that may affect measurement and utility of a dietary biomarker to properly reflect dietary exposures in individuals or target populations (from Jenab *et al.*, 2009)

Genetic variability	• Genes that may affect dietary intake patterns, taste, attraction to specific foods or food types etc. • Biological variation in nutrient absorption, metabolism, tissue turnover, excretion • Epigenetic variation, gene-gene interactions
Lifestyle or physiological factors	• Smoking, alcohol consumption, exercise, gender, age, body weight/size, socioeconomic status • Influence of colonic microbiota (bioconversion, release of bioactive dietary compounds) • Enterohepatic circulation of nutrients (e.g. phytoestrogens, lignans)
Dietary factors	• Range or frequency of intake of a particular nutrient • Nutrient-nutrient interactions • Nutrient bioavailability, influence of food matrix
Biological sample	• Type of sample collected for analysis of biomarker (e.g. whole blood, plasma, serum, urine) • Conditions of sample collection, transport, treatment, storage conditions, length of storage • Diurnal variation, day of the week or season of sample collection
Analytical methodology	• Precision, accuracy, detection limits of analytical technique • Variations from method to method or laboratory to laboratory

1.3.1.2. Direct dietary observation

Direct dietary observation of subjects eating meals provides a reliable way of recording diet intake, free from subject associated bias[1], without the need for expensive biomarkers and access to laboratory equipment. Although this method is a subjective method, as it relies on observer interpretation, it is considered a suitable reference method for the validation of self-reported methods of diet assessment (Baglio *et al.*, 2004). The method involves trained observers watching subjects during meal times and recording food items selected, portion sizes and the amount actually eaten, spilled or traded (given away/received) at the time of

[1] See table 1.7 for a summary of biases associated with dietary and physical activity assessment

consumption during a specified time period or meal. This data can then be analysed using appropriate dietary analysis software.

The direct dietary observation method is most commonly used in populations of children by observing meals during school time (Baranowski *et al.*, 2002; Baxter *et al.*, 2002; Baxter *et al.*, 2007; Domel *et al.*, 1994; Smith *et al.*, 2007; Warren *et al.*, 2003). School meals provide an excellent opportunity for observation as children are accustomed to being watched while eating at school and they are provided with foods that they would normally be served, therefore reducing the chance of changes in eating behaviour. In addition, a significant percentage of children's total daily intake is consumed at school (Baxter *et al.*, 2002). Direct dietary observation in adult groups is more problematic and appears to be less common, especially in free-living situations. Direct observation has been used in the validation of the 24 hour multiple pass recall dietary interview in adults (Conway *et al.*, 2003; Conway *et al.*, 2004). In these studies, foods were consumed at a research centre which may have not only influenced eating behaviour but may have also enhanced recall as the food items consumed were associated with a 'special' or 'unusual' event.

The main advantages of direct dietary observation are that no expensive equipment is needed; there is little subject burden if usual meal time is observed (e.g. school/work meal time); and, as previously mentioned, there is no subject associated bias involved (subjects are not asked to report anything). However, direct dietary observation is subject to observer associated bias. It is essential that time is taken for observers to be trained prior to observation sessions, and, if a number of observers are being used, inter-observer reliability is assessed (Baglio *et al.*, 2004). Other disadvantages include subject discomfort at being watched when eating (which may be more of a problem in adult populations); realistically only certain meals, at specific times, can be observed; potential sample bias may occur if targeting groups that typically have specific meal times in specific locations (e.g. in a workplace); and subjects may change their eating behaviour if they know they are being observed (attention bias).
Direct observation is unsuitable for the measurement of habitual dietary intake as measurement is restricted to specific meals (although it may provide indicators of

habitual diet). This method is therefore mainly used as a reference method for validation studies, where agreement between foods observed and those reported for the specified meal is investigated. Direct observation was used to evaluate a family based healthy lifestyle intervention, by observing intervention families with families who had not received the intervention during a zoo trip (Patterson *et al.*, 1988). Nowadays, similar procedures may be limited or unsuitable because of ethical constraints.

1.3.1.3. Concurrent self-report

Duplicate diets

The duplicate diet method involves subjects concurrently collecting duplicate portions of all the foods and drinks that they consume over a specified period. The duplicate meals are homogenised together and analysed using bomb calorimetry to determine exact nutrient composition of the whole diet during the collection period. All foods and drinks consumed need to be weighed so that exact portion sizes can be replicated. Subjects are usually asked to also keep a weighed food record as this can serve as a method to check the completeness of the duplicate diet.

The duplicate diet method is extremely accurate as exact values of macronutrients and micronutrients can be determined. There are no errors resulting from coding and data input, and no reliance on food composition tables or nutritional databases. However, the duplicate diet method is still, in essence, a self-report method and will be affected by the subject associated bias. The method is highly burdensome for the subject, so subjects need to be highly motivated. The method also relies on subjects providing duplicates of exactly the same foods and drinks and weights consumed. Subjects may change usual behaviour to reduce burden and also in response to knowing that their diet is being measured (attention bias). This method is also unlikely to be able to measure habitual dietary intake levels as it is unlikely that the number of days required will be measured because of the high burden imposed on the subject.

The duplicate diet method is also very expensive to carry out requiring specialised laboratory equipment and expertise. There are also some practical considerations that need to be taken into account when using this method, such as how the duplicate portions will be stored by the subject (storage bags, non-leak bottles, ice packs and insulated bags are often provided) (Lightowler and Davies, 2002) and how and when samples will be collected, stored and processed.

This method is ideal for the study of specific subgroups and specific nutrients. However, owing to its limitations, it is not suitable for large scale studies or surveys, smaller studies with limited budget and resources, and/or studies aiming to include less motivated individuals.

Food record

<u>Weighed food record</u>

The weighed food record (or diary) is a prospective method where foods and drinks (and leftovers) are weighed and recorded at the time of consumption. This method was traditionally considered a gold-standard method of measuring food intake. However, there are disadvantages involved in this method and other methods such as doubly labelled water, biomarkers and direct diet observation may now be considered more preferable reference methods.

The accuracy of a weighed food record relies greatly on the co-operation of the subject. Weighing all foods and drinks before consumption can be extremely burdensome and in some cases very inconvenient (for example, when eating in a restaurant) and this has been reported to affect the motivation of subjects to continue in a study (Livingstone *et al.*, 1990). If a subject is not motivated to complete the record, no data will be collected. Variable recording periods are required to obtain an accurate measure of habitual dietary behaviours, with the number of days depending on the nutrient being measured and the population in which it is being measured, ranging between 2 to 280 days (Nelson *et al.*, 1989). However, it is considered reasonable to ask for up to seven days of recording, with a minimum of three days (two week days and one weekend day) (Bingham, 1987).

Another disadvantage associated with weighed food records is that subjects have been reported to change their eating behaviour. In some cases this may involve consuming foods and drinks that are easier to measure; and also foods and drinks that are perceived to be ‘healthier’ (Macdiarmid and Blundell, 1997). There is also the risk of subjects forgetting (intentionally or not) to weigh and record items.

Non-weighed food record

As a way of reducing some of the burden involved in weighed records, records can be used where descriptions of portion sizes are recorded instead of the actual weight, eliminating the weighing process. Portion size descriptions may be given in terms of standard household measures which can be converted into known weights (Ministry of Agriculture Fisheries and Food, 1993), or using portion sizes estimated from a food photography atlas (Nelson *et al.*, 1997) or food models.

Although this method is less burdensome than the weighed-record, it still involves significant burden. Additional error is introduced through the reliance on subjects to accurately describe and/or estimate portion sizes, requiring some degree of numeracy and literacy skills. As with weighed records, eating behaviour may change during the recording period and some items may not be recorded, especially small items such as condiments and spreads.

Data from both types of food record are analysed using suitable nutritional software containing country specific nutritional composition databases. The accuracy of the items reported being coded to the appropriate nutritional value relies on the description of the foods provided by the subject. If insufficient description is given, the researcher will have to make assumptions which will affect the reliability of the resulting outcome values. For example if ‘Cola’ is reported, the researcher may assume that this is ‘regular’ Cola, when in reality the subject may have consumed ‘diet’ Cola, which will have a significantly lower energy and sugar content, or, it might be decided that the data is excluded due to the inability to code the item accurately. Taking additional time to check through diaries with subjects before the data is analysed, ensures that important information is collected.

Photography

A relatively recent addition to dietary assessment methodology is the use of real-time photography (commonly used in addition to estimated food records) to determine portion sizes and actual intake (Hunt *et al.*, 2008; Martin *et al.*, 2009; Small *et al.*, 2009; Williamson *et al.*, 2003). This involves photographing food items selected for an eating occasion (before eating) and photographing waste left after the eating occasion, along with a reference marker of known size or reference portion of known weight. The photographs are used by trained researchers (preferably nutritionists or dietitians) to determine the portion size of the foods by comparing the photographs with standard portion photographs. The estimated portion sizes are then used when inputting the data into dietary analysis software.

Advantages of this method are: that it can be used in free-living populations at anytime (not restricted to certain meal times as in observation e.g. school/workplace meals); it has reasonably low burden; and it does not rely on portion sizes estimated by subjects. The equipment associated with this method is also considered to be relatively inexpensive and existing technology can be utilised such as digital cameras incorporated in personal digital assistants (PDAs) and mobile phones. Photographs can then be sent instantly along with descriptions of the foods, eliminating the need for paper diaries and potentially allowing researchers to respond immediately if more information is required. However, this method does rely on subjects remembering to take the photographs and send/record additional description notes (e.g. cooking method, hidden ingredients, etc); and a large amount of staff time is required for the coding of the photographs and data entry into a nutritional software package. Messages/prompts can be used to help remind subjects, however these are not always received when desired and some missing data is inevitable (Martin *et al.*, 2009). Currently, computer applications are being developed that can send these messages automatically and monitor incoming data, alerting researcher and the subject if data is incomplete, which will result in a significant reduction in staff time/burden (Martin *et al.*, 2009). Further work is currently being carried out to develop computer systems that can recognise the food photographed and estimate portion sizes automatically (Boushey *et al.*, 2009). However, it is likely to take some time to develop this method so that a wide range of foods can be detected.

1.3.1.4. Retrospective self-report

24 hour recall

The 24 hour recall is an interview-based technique where subjects are asked by a researcher to recall foods and drinks consumed in the previous 24 hours, or, more usually, during the previous day. Traditionally, 24 hour recalls were completely open ended, using a blank sheet of paper. However, in recent years 24 hour recalls have tended to follow the more standardised multiple pass recall dietary interview where a number of stages (or passes) are used to stimulate the subject's memory and reduce the number of forgotten eating occasions (Moshfegh *et al.*, 1999). The multiple pass recall dietary interview comprises of five main stages starting with the initial 'quick list' where subjects list all foods and drinks consumed, without the need for detailed information. The next stage is the forgotten foods list where subjects are given a list of commonly forgotten foods, which may stimulate recall of forgotten items that can then be added to the quick list. Details of the time and name of each eating occasion are then obtained, followed by the detailed pass stage where further detail on each food item is collected. During the detailed pass, probing questions are used to obtain detailed information on each food item, for example, if it was a specific type of the food item (diet, low fat, wholemeal, semi-skimmed etc), brand names if applicable, and cooking methods. Portion sizes are also estimated (usually using portion size estimation aids such as models, photographs, plates, cups spoons etc) during this stage. Finally, the intake for the day is reviewed allowing for another opportunity to add any information previously missed.

The 24 hour recall method relies heavily on the subject's ability to remember the foods and drinks they consumed the previous day, and their ability to estimate portion sizes. The advantage of a researcher-based interview is that the researcher is able to help prompt the subject to recall commonly forgotten foods and also obtain important information that the subject may not have otherwise thought to report. Thus complete data can be obtained in one session without the need to re-contact the subject at a later time when memory of the event may also be less vivid. Other advantages of this method are that administration time is relatively short (approximately 15 to 20 minutes); minimum literacy skills are required of the subject; interviews are open ended so as much information as required can be collected; and, if interviews are carried out on random days, i.e. subjects do not know which day(s) will be recalled, dietary change due to attention bias may be reduced.

However, the need for trained interviewers can also be a disadvantage, particularly in regard to the increase in staff costs. Training is required for all staff carrying out interviews (and ideally some measure of inter-interviewer reliability would be taken) increasing costs still further, both in terms of staff time and the cost of the training itself. The presence of an interviewer may also introduce social desirability bias (unacceptability and obsequiousness bias), in that the subject may report a more favourable diet than that they actually consumed. The accuracy of the recall will also rely on the ability of the interviewer to ask the correct probing questions, although this may be overcome in part by providing a script (as is often used in the multiple pass recall dietary interview). However, not all responses can be scripted and some probing questions will rely on the interviewer's knowledge, experience and training. Other factors that may come into play, but are difficult to document, are question wording, incorrect use of probing questions, verbal or other reactions to answers given by the subject and inability to establish a relationship with the subject (Slimani *et al.*, 2000).

Another weakness is that an individual's usual intake cannot be assessed from one day's intake. Also, traditional 24 hour recall methods have also been shown to underestimate dietary intakes in western adult populations (Bingham *et al.*, 1995; Johansson *et al.*, 2001). However, 24 hour recalls are a popular choice and in 2002 the European food consumption survey method (EFCOSUM) Group carried out a review of the literature with the aim of developing a dietary assessment method that could be used as a standard method for measuring food intake (acute and usual consumption levels) in European countries (Biro *et al.*, 2002). The group concluded that the 24 hour recall method was the best method for measuring population mean intakes and distributions in subjects aged 10 years and over.

Food Frequency Questionnaire

A food frequency questionnaire (FFQ) is *"a questionnaire in which the respondent is presented with a list of foods and is required to say how often each is eaten in broad terms such as x times per day/per week/per month, etc. Foods chosen are usually chosen for the specific purposes of a study and may not assess total diet"* (Margetts and Nelson, 1997). The most commonly used FFQ's, or adaptations of these questionnaires, are the National Cancer Institute/Block Health Habits and History Questionnaire (Block *et al.*, 1986); and the Harvard Semiquantitative Food Frequency Questionnaires (Willett *et al.*, 1987).

FFQ's are not advisable for use in studies with small numbers of subjects; for surveillance and monitoring of current levels where accurate absolute intakes are required; using a FFQ developed in one country unless dietary habits are very similar; and in some clinical work where precise intakes are required (Cade *et al.*, 2002).

Advantages of FFQ's include convenient analysis when a scanning system is used. Also, there is reasonably low burden on subjects as the FFQ only needs to be completed once at each time point, though the questionnaires can take a long time to complete. Some FFQ's can also now be self-administered as a paper version or electronically. Disadvantages are that this method is fairly inflexible as reported intake is limited to the foods contained in the food list and unusual food intake patterns may be missed; misclassification can result from food groupings (although this is mainly when looking at vitamin/mineral content); it is generally only applicable to specific populations and time period; accurate reporting relies on the subject's memory; and a certain degree of literacy and numeracy skills are required if self-administered.

Diet-history

The term 'diet-history' is often mistakenly used to describe food frequency questionnaires that collect data on foods and drinks consumed, and frequency, over a longer period of time, usually the previous year. However, the term is properly used for methods *"that are designed to ascertain a person's usual food intake in which many details about characteristics of foods as usually consumed are assessed in addition to frequency and amount of food"* (Thompson & Subar, 2008, p11). Diet history methods are relatively complex, using a number of components. Burke and colleagues pioneered the diet history method, with the Burke Diet History that consisted of a detailed interview, a food-frequency checklist and a 3-day diet record (Burke, 1947). During the detailed interview, subjects are encouraged to talk through a usual day, describing the foods and drinks usually consumed at each meal time. The food-frequency checklist and diet records are then used to cross-check the data reported during the interview. More recent adaptations of Burke's original method are now commonly used such as the CARDIA diet history (McDonald *et al.*, 1991), with many methods now becoming 'computerised' (Landig *et al.*, 1998; Slattery *et al.*, 1994). Diet histories are usually administered by a trained interviewer (usually a dietitian or nutritionist), although some self-administered methods now exist.

The main advantage of a diet history method is that it collects data on meal patterns and food intake, including preparation/cooking methods, rather than just frequency, as in a FFQ, and data is collected for a longer period of time than a 24-hour recall or diet record. Information is collected for each meal, which allows for analysis of food interactions (e.g. iron absorption affected by tea or vitamin C foods consumed at the same time) and possibly improved recall (total intakes may be better recalled when intakes are recalled on a meal by meal basis). Another advantage is the fact that it contains multiple methods, which are used to cross check the data provided in the initial interview.

One significant disadvantage of this method is that it is very difficult to recall 'usual' behaviour, and it relies heavily on the subject's memory and judgement. As with many of the other dietary assessment methods, trained interviewers are often required to administer this method and the data processing and analysis can be highly burdensome on research staff.

Table 1.5 Summary of advantages and disadvantages of dietary assessment methods

Method	Advantages	Disadvantages
Doubly labelled water	Objective Highly accurate Suitable for free-living populations No subject associated bias No reactivity bias	Expensive Specialised knowledge, equipment and facilities required Cannot measure sub-domains of diet: e.g. macro or micro-nutrients, specific food groups Urine samples required – subjects may find unpleasant
Biomarkers	Objective Accurate Suitable for free-living populations No subject associated bias No reactivity bias	Specialised knowledge, equipment and facilities required Blood or urine samples required – subjects (and researchers) may find unpleasant Currently few biomarkers with established relationships with nutrients
Duplicate diets	Accurate Subject not required to describe foods or estimate portion size	Expensive Specialised laboratory facilities required High subject burden (potential non-completion, behaviour change to reduce burden) Relies on subject to provide complete samples Potential reactivity bias
Direct observation	No expensive/specialised equipment required Relatively objective and reliable No subject reporting bias Little subject burden Ideal in child populations – easily incorporated into school day with little disruption or change in normal behaviour	Trained observers required (time required for training and reliability testing) Potential observer bias (reduced by training and reliability assessment) Practically cannot collect all food intake during 24 hrs More difficult in adult populations Intrusive Some foods easier to observe then others Diet behaviour may be changed over measurement period (social desirability) Researcher time required to code and input data into dietary software package
Diet records (weighed and non-weighed)	No expensive/specialised equipment required Relatively low burden (non-weighed method) Collects data on diet of whole day Collects data on diet sub-domains	High burden (weighed method) Diet behaviour may changed over measurement period (eat foods easier to weigh; social desirability) Relies on subject to complete fully and accurately Researcher time required to code and input data into dietary software package Literacy and numeracy skills required

Table 1.5 (continued) Summary of advantages and disadvantages of dietary assessment methods

Method	Advantages	Disadvantages
24 hour recall	No expensive/specialised equipment required Relatively low burden Collects data on diet of whole day Collects data on diet sub-domains Reduced chance of diet changing if recalls are random	Trained interviewer required (time required for training and reliability testing) Relies on subject's ability to remember past behaviour Relies on subject's ability to estimate portion size May be affected by social desirability biases Researcher time required to code and input data into dietary software package
Food frequency questionnaire	No expensive/specialised equipment required Relatively low burden Collects data on habitual behaviour Automatic data processing available	Relies on subject's ability to remember past behaviour over a long time period Minimal literacy and numeracy skills required
Diet history	No expensive/specialised equipment required Collects data on habitual behaviour including data on meal patterns Multiple methods can be used to cross check	Relies on subject's ability to remember past behaviour over a long time period and recall usual behaviour Trained interviewers required

1.3.2. Physical activity assessment methods

Methods of physical activity assessment can be grouped into five general categories:

- Calorimetry
- Physiological markers (e.g. heart rate)
- Motion sensors
- Behavioural observation
- Self-report (including diaries, recall questionnaires and interviews)

A summary of the advantages and disadvantages of each method is provided in table 1.6.

1.3.2.1. Calorimetry

The most accurate (criterion) way of measuring energy expenditure is calorimetry by either measuring heat production (direct calorimetry) or gas exchange (indirect calorimetry). Direct calorimetry involves the subject living in the chamber for 24 hour periods while energy expenditure is measured for all activities carried out, including sleeping and eating. Obviously, this method is of no use for measuring activities in free-living/usual activities (unless the subject usually spends their days confined to a small room!) but is useful for determining energy expenditure values for specific activities that can then be applied to other measurement methods.

Cart-based and portable metabolic systems exist that measure gas exchange, for example the Delatrac II^{TM} metabolic cart (Datax-Ohmeda Division, Finland) and the Cosmed K4 b^2 (COSMED, Rome, Itlay), which allows some flexibility on the types, and location, of activities that can be carried out. However, these systems still require specialised equipment and personnel and even a portable system would be impractical to wear and a carry in real-life situations. Therefore, these methods are not feasible for the measurement of habitual physical activity in free-living populations.

Doubly labelled water

Doubly labelled water is a form of indirect calorimetry and is well established as the criterion method for assessment of total energy expenditure in free-living populations (Bluck, 2008). The basic principle for the doubly labelled water method is as follows: the subject consumes a loading dose of water labelled with the stable isotopes ^{18}O and deuterium (^{2}H). The ^{18}O isotope is eliminated from the body as water *and* carbon dioxide, whereas the deuterium is eliminated as water only, so the rates of turnover for each isotope will differ. The difference between the two elimination rates is proportional to the rate of carbon dioxide production (Coward, 1988). The rate of carbon dioxide production, along with an estimate of the respiratory quotient, can then be used to calculate total energy expenditure (and other components of material balance such as water intake and oxygen consumption) using standard indirect calorimetric methods (Schoeller and van Santen, 1982; Schoeller, 1988).

The doubly labelled water method is relatively simple and non-invasive, requiring only periodic sampling of body fluids, and can be used for up to 14 days (Speakman, 1997). The method is accurate with a precision of 2-8% depending on the isotope dose and the length of the elimination period (Schoeller, 1988). One disadvantage of the doubly labelled water method is that, although accurate measures of total energy expenditure are achieved, it cannot provide information on the types, frequency and intensity of activities carried out.

Activity energy expenditure is calculated from the measurement of total energy expenditure obtained after subtracting the energy requirements for food digestion (usually assumed to be 10% of total energy expenditure) and a measure of the individual's basal metabolic rate (BMR), that can either be measured directly (for example using gas exchange indirect calorimetry) or using established equations (for example (Schofield, 1985)). This calculation of activity energy expenditure, therefore, can only be an indirect measure as errors are associated with the estimation of these additional variables and all are influenced by subject's body mass and energy economy (Schutz *et al.*, 2001). Possibly the biggest disadvantage of the doubly labelled water method is the costs involved for the isotopes, analysis and equipment required. These tend to be well beyond the average research budget, making this method unfeasible for large scale studies in free-living populations. Nowadays, doubly labelled water is most commonly used as a criterion method for validation studies of other methods of physical activity (and dietary) assessment where only small numbers are required.

1.3.2.2. Motion sensors and physiological markers

Accelerometry

Description

Accelerometers fall into the category of motion sensors. Accelerometers measure the acceleration, a change in velocity with respect to time (m/s^2), of movement and use this to quantify the intensity of the movement (Corder *et al.*, 2007). When a person moves, the body is accelerated in relation to the muscular forces responsible for the acceleration of the body, and therefore theoretically in relation to energy expenditure. The output from accelerometers is a ‘count’ value calculated from a filtered digitized acceleration signal, defined over a user-specified time interval, commonly referred to as an epoch. The summed value or activity count is written to memory at the end of each epoch (Trost *et al.*, 2005).

The majority of accelerometers are uniaxial and are sensitive to movement in the vertical axis but some are also sensitive to acceleration in the anterior-posterior and/or mediolateral planes (biaxial and triaxial). However, these monitors are primarily uniaxial as they are most sensitive to vertical movement (Corder *et al.*, 2007).

Accelerometry calibration and validation studies in adults

Calibration studies determine the relationship between accelerometry counts and energy expenditure measured by criterion methods for specific activities, so that raw activity counts can be translated into outcomes that are physiologically meaningful. Calibration studies usually compare activity counts with oxygen consumption in laboratory conditions, however, different studies have used different activities and/or intensities, from treadmill walking and running (Brage *et al.*, 2003; Freedson *et al.*, 1998; Leenders *et al.*, 2003; Nichols *et al.*, 2000; Yngve *et al.*, 2003) to track walking/running (Hendleman *et al.*, 2000; Nichols *et al.*, 2000; Yngve *et al.*, 2003) replicated free-living 'lifestyle' activities (Hendleman *et al.*, 2000; Swartz *et al.*, 2000).

The variation in activity types and intensities used in the accelerometry calibration studies, has resulted in a great deal of disparity between equations and cut points that have been determined, even within studies that have used the same monitor. Moderate-intensity cut offs for Actigraph vary as much as 10-fold (Matthews, 2005). Some studies suggest that calibration cut-points established using laboratory settings may not be suitable for activities carried out in the field (Nichols *et al.*, 2000; Yngve *et al.*, 2003) and that cut-points established using walking protocols are not suitable for free-living activities (Hendleman *et al.*, 2000). The fundamental issue related to determining cut-points for accelerometry is that although it is useful to convert accelerometry counts into a physiological meaningful measure, accelerometry will never be a physiological measure as it assesses a biomechanical aspect of physical activity (Corder *et al.*, 2007).

Many validation studies in adults have also been carried out with various accelerometry monitors in free-living conditions over one day (Chen *et al.*, 2003; Welk *et al.*, 2003; Welk *et al.*, 2007) and multiple days (Leenders *et al.*, 2001; Masse *et al.*, 2004; Plasqui *et al.*, 2005). The results of these validation studies vary greatly because of variations in protocols, methods of analysis and data interpretation, making conclusions difficult.

Overall, higher correlations are observed for walking and running than for lifestyle activities such as household tasks and light occupational activities that involve complex movement patterns. However, correlations become weaker at high speed/intensity running, where a levelling off effect is observed (count measurement remains the same as intensity increases). This is not a major concern for public health epidemiologists as running is not a common activity carried out by the majority of the public. Also, if categorising activities as 'sedentary', 'light', 'moderate' or 'vigorous', running at a high speed will always be classified as vigorous, regardless of whether the true energy expenditure or MET is calculated.

The development of multiple axis accelerometers was thought to overcome the weakness of uniaxial monitors being unable to capture more complex movement involved in lifestyle activities (Matthews, 2005). However, despite marginally higher validity coefficients reported for multiple axis monitors compared with uniaxial monitors (Trost *et al.*, 2005), it appears that the additional information captured does not remedy the problem of underestimation of these activities. In a study by Welk et al. (Welk *et al.*, 2000b), both unixial and triaxial monitors underestimated the energy cost of sweeping, vaccuming, stacking, raking and shovelling by about 50%. Most studies report a positive correlation between the output from both accelerometer types, suggesting that uniaxial and multiple axis accelerometers provide comparable physical activity information (Trost *et al.*, 2005). However, sedentary activities may be better reflected using triaxial accelerometry (Westerterp, 1999).

Using Accelerometers in field-based research

When using accelerometers in field-based research in free living populations, a number of questions need to be asked; it is not just a *'plug and play'* proposition (Trost et al 2005 p1). Decisions need to be made regarding the type of accelerometer used; how many accelerometers are used; where the accelerometer(s) will be positioned; the epoch length used; and the number of days the accelerometer will be worn. Once these decisions are made, it is then important to plan how the data will be collected and processed (including which cut-points are used and how missing data is dealt with); how the accelerometers will be distributed to subjects and then returned to the research team; clear written or verbal instructions telling subject how and when to wear the accelerometer; and strategies to promote compliance and minimise missing data.

Monitor choice

All commercially available accelerometers show some evidence of validity and reliability; however, because of a lack of studies comparing the output of each model directly, it is not possible to identify one superior accelerometer model (Corder *et al.*, 2007). Decisions are, therefore, usually made dependent on the price of monitor (and associated extras), size and sturdiness of monitor, usability of the monitor and processing software, and availability of technical support (Trost *et al.*, 2005).

In the review by Trost and colleagues (Trost *et al.*, 2005), nearly all studies reviewed reported high levels of inter-instrument reliability. These studies ranged from investigation of monitors placed on opposite hips to more sophisticated methods using oscillating devices. However, there was evidence to suggest that inter-unit variability increases significantly at very low and very high levels of movement, and it is recommended that researchers routinely calibrate their accelerometers and keep track of monitors used by subjects by recording serial numbers (Trost *et al.*, 2005).

<u>Number and placement of monitors</u>

In theory, multiple monitors placed at different sites on the body should result in more accurate measurement as different body sites are differently active (Westerterp, 1999). However, studies investigating the ability of multiple monitors to estimate physical activity have only observed marginal advantages that do not outweigh the subject burden associated with wearing multiple monitors (Trost *et al.*, 2005) and the time required to process and analyse the additional data (Swartz *et al.*, 2000).

Theoretically, placement of the accelerometer close to the centre of mass of the body is the optimal choice (Westerterp, 1999). In the review by Trost and colleagues (Trost *et al.*, 2005), one study reviewed found that accelerometer counts were more strongly associated with observed energy expenditure when hip and back placements were used, compared with placement on lower leg/foot, upper leg, head and trunk, lower arm/hand and upper arm (Bouten *et al.*, 1997). Other studies, investigating differences between hip and back, and different hip placements found some small but significant differences for the measurement of certain activities in some conditions, but also no significant differences for others (Nilsson *et al.*, 2002; Welk *et al.*, 2000a; Yngve *et al.*, 2003). The practical significance of the differences, however, is questionable (Trost *et al.*, 2005).

Epoch

One minute epoch are most commonly used in studies using accelerometers to estimate physical activity intensity or energy expenditure, which makes it easy for activity counts to be converted to minutes of activity. It is established that this is suitable for assessments in adults, although this has not been studied systematically (Trost *et al.*, 2005). One minute epoch are considered to be unsuitable for assessment in children as short bursts of activity often exhibited by children may be missed (Trost, 2001; Welk *et al.*, 2000a).

Cutpoints (for adults)

Cut points are used to translate raw activity counts into physiologically meaningful information (for example moderate and vigorous intensity activities so that total minutes of moderate to vigorous physical activity can be calculated). As discussed earlier, the calibration studies that have attempted to determine these values have resulted in a variety of cut points (Matthews, 2005). For the National Health and Nutrition Examination Survey (NHANES) 2003-2004 (Troiano *et al.*, 2008), cut-offs were calculated as a weighted average of criteria determined from four calibration studies (Brage *et al.*, 2003; Freedson *et al.*, 1998; Leenders *et al.*, 2001; Yngve *et al.*, 2003). These cut offs were also applied to the accelerometry data collected as part of the Health Survey for England (Craig *et al.*, 2009).

Advantages and limitations

The main advantages of accelerometry is that it produces an objective measure of physical activity and is suitable for measurement in large populations, for periods of time long enough to be representative of normal life and with minimal subject burden (Westerterp, 1999). Accelerometry is measured in real-time and provides information on the frequency and duration of physical activity of different intensities.

The main limitation of accelerometry is the inability to capture non-ambulatory activity (for example, cycling and weight training); complex activity patterns involved in lifestyle activities (which involve both ambulatory and non-ambulatory movement); load carrying activities; and activities carried out on a gradient. Accelerometry will also never capture data on activities when monitors cannot be worn (for example, swimming and high contact sports such as rugby). It may be possible to account for more structured activities such as cycling, weight training, swimming and high contact sports, through self-report, and as it is believed there is a relatively low prevalence of theses types of activities, this limitation of accelerometry is not a major concern of public health epidemiologists. The inability to capture lifestyle activities is however more of a issue as these activities are carried out frequently, therefore providing a significant contribution to overall energy expenditure, but are difficult to describe accurately through self-report (Matthews, 2005).

Another weakness of accelerometry (and any other motion sensor) is that it does not provide any contextual information about the type or purpose of the activity. This information is required if specific types or domains of activity are of interest, for example transport activity, occupational activity, television watching, etc. This may be of interest in observational studies that investigate relationships between domains of activity and health, and interventional studies where a particular type or domain of activity is targeted, for example active commuting.

Combined heart rate and accelerometry

Heart rate is a physiological variable that has a well-established relationship to oxygen consumption, and can be used alone as a method of measuring physical activity. Energy expenditure can be estimated from heart rate data using regression equations derived from individual and group calibrations. However, there are some limitations in using heart rate measures alone. The main disadvantages are that the linear relationship between heart rate and energy expenditure is reliable during activities of high intensity but questionable during low intensity activities where it may be affected by emotional state such as anxiety or stress; and that the heart rate response tends to be delayed after changes in movement and also remains elevated after movement stops and, therefore, sporadic movement may not be captured. The combination of physiological measurement and motion sensors is a promising approach to physical activity assessment as the weaknesses of each method can be counter balanced by the capabilities of the other. In particular, the combination of heart rate and accelerometry has been investigated and is becoming an established method of assessment.

Monitors available

The principles of combined heart rate and accelerometry monitoring can be applied regardless of the devices used to measure each variable. Separate monitors can be used (for example a heart rate monitor worn around the chest and an accelerometer unit worn on the hip), however the development of combined sensors may reduce burden for both subject and researcher. The first commercially available combined sensor was the Actiheart® device (CamNtech, Cambridge, UK) and this monitor is mainly described in the current literature, although others are emerging (Berntsen *et al.*, 2010).

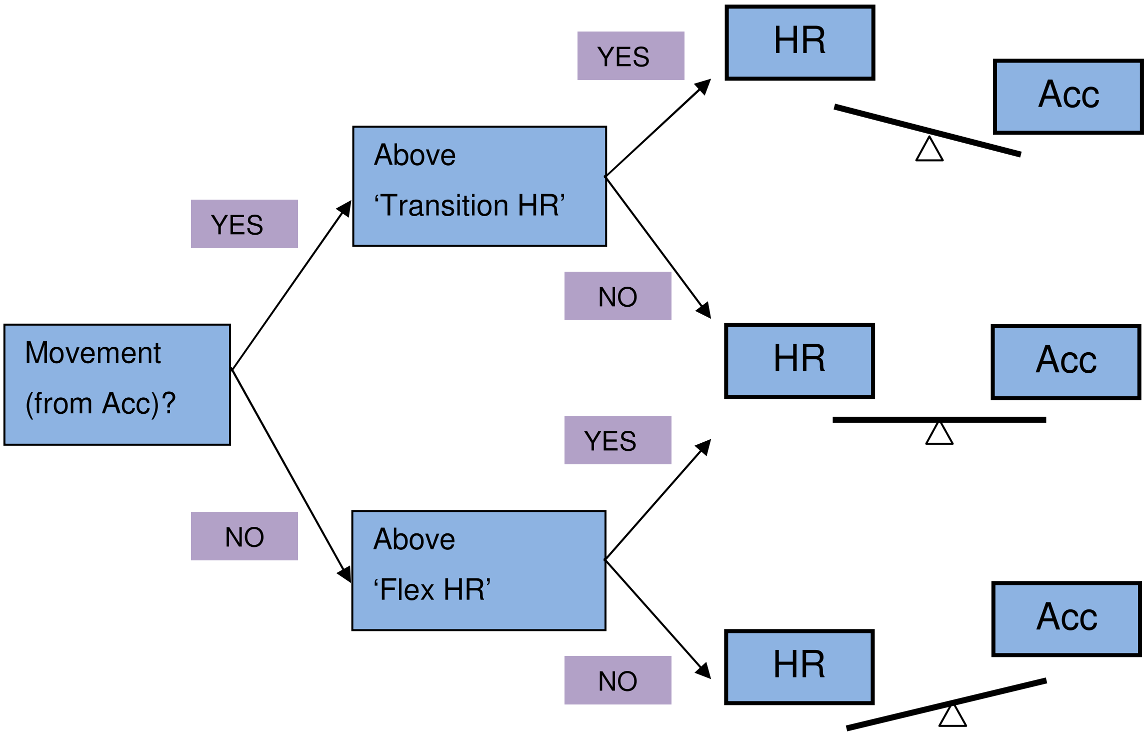
Validation studies

A number of studies have shown that the combining heart rate and measurements of movement improves the estimation of energy expenditure in adults (Avons *et al.*, 1988; Haskell *et al.*, 1993; Luke *et al.*, 1997; Strath *et al.*, 2001; Strath *et al.*, 2002), especially in simulated activities of daily living (Assah *et al.*, 2010; Luke *et al.*, 1997; Strath *et al.*, 2001; Strath *et al.*, 2002). Validation studies of the Actiheart® monitor have shown accurate estimates of treadmill walking and running (Brage *et al.*, 2005); laboratory simulated low-to-moderate activities (Thompson *et al.*, 2006); a wide range of activities in a field setting (Crouter *et al.*, 2007); and free-living activity (Assah *et al.*, 2010).

Branched equation

The branched equation developed by Brage and colleagues (Brage *et al.*, 2004) is used in combined heart rate and accelerometry monitoring to yield accurate estimates of energy expenditure (Crouter *et al.*, 2007; Thompson *et al.*, 2006). A detailed description is given in the paper by Brage and colleagues (Brage *et al.*, 2004), however in simple terms, the branched equation is a decision tree for determining

Figure 1.6 Branched equation model for combined heart rate and accelerometry monitoring (adapted from Brage *et al.* 2004)



the weighting of physical activity intensity as determined by heart rate verses physical activity intensity as determined by accelerometry, in the calculation of overall physical activity energy expenditure (figure 1.6). The branched equation model is incorporated into the Actiheart® software for the calculation of activity energy expenditure.

<u>Using combined heart rate and accelerometry in field-based research</u>

As with accelerometer monitors (or any type of monitor worn in a free-living population) when using combined heart rate and accelerometry in the field a number of practical decisions need to be made; such as which monitor(s) are to be used, the number of days the monitor will be worn, and how the monitor will be distributed and collected. Unlike accelerometers, combined heart rate and accelerometer monitors need more time to set-up and time is needed if an individual calibration test is to be carried out. If the monitor is to be attached to electrocardiogram (ECG) electrodes, time is needed to prepare the subject's skin before attachment to ensure a clear heart rate signal is detected. A signal test is advised to confirm that the monitor is detecting a clear signal before the monitor is programmed for the recording period. Laptops/PCs containing the appropriate software will need to be accessible during the set-up, which may need some consideration if this is to be carried out in the field. Clear instructions on changing the electrodes should be provided along with sufficient spare electrodes for the recording period. Addition data such as height and weight may also be required when programming the monitor for the individual, so suitable equipment will be necessary to take these measurements.

Advantages and limitations

The main advantage of combined heart rate and accelerometry is that it provides an objective measure of total physical activity and an accurate estimate of energy expenditure during physical activity that has been shown to be reliable and valid at both individual and group level. Information on activity patterns can also be provided. Combined, single piece devices are reasonably low burden for subjects; have storage capacity of at least seven days; and are waterproof, eliminating the need for removal. Non-wear time is also easily identifiable.

Heart rate is not always easy to pick up and the measurement may be quite ‘noisy’, requiring careful interpretation and expert advice (Stegle *et al.*, 2008). Individual calibration is required for increased accuracy of energy expenditure estimations as heart rate is influenced by individual fitness level. However, individual calibration can be achieved with a simple step or walk tests that are easily carried out in the field (Brage *et al.*, 2007). Electrodes may cause adverse skin reactions resulting in drop outs. Finally, combined devices are relatively expensive therefore often beyond the budget of smaller research/evaluation groups.

1.3.2.3. Observation

Direct observation has been used as a reference method for the assessment of physical activity in children. This method provides rich contextual data (for example, behavioural cues, environmental conditions, presence of significant others), however it is a subjective method that relies on the interpretation of the observer therefore is unsuitable for the estimate of intensity or energy expenditure. A number of protocols exist, including the Activity Patterns and Energy

Expenditure (APEE) (Epstein *et al.*, 1984); Children's Physical Activity Form (CPAF) (O'Hara *et al.*, 1989); Children's Activity Rating Scale (CARS) (Puhl *et al.*, 1990); the Level and Tempo of Children's Activity (LETO) (Bailey *et al.*, 1995); and System for Observing Play and Recreation in Communities (SOPARC) (McKenzie *et al.*, 2006). The coding process can be labour intensive; however, systems are now used so that data can be inputted into appropriate software via laptops or personal digital assistants (PDAs) concurrently in the field (McKenzie *et al.*, 2006). Direct observation requires trained observers and can only be carried out in controlled settings, with the possibility of reactivity bias, therefore is unsuitable for the assessment of free-living activity. Direct observation has been used as a reference method for comparison studies (Baranowski, 1988) and also for intervention evaluation (Patterson *et al.*, 1988).

1.3.2.4. Self-report methods: Questionnaires, recall interviews and diaries

Self-report methods, mainly questionnaires, have been most commonly used in large scale studies where paper methods can be distributed to large numbers relatively cheaply. These methods are most useful for capturing data on physical activity patterns, frequency, type and context (Livingstone et al. 2003). There are many limitations to these methods as they rely on the subject's ability to recall behaviour accurately, which may be affected by memory and social desirability. Activities that are structured and related to a particular timeframe, for example a gym session, participation in a sport or active travel, tend be easier to recall. Sedentary and light-to-moderate activities that are hard to define and carried out sporadically during the day, such as occupational activities and household tasks, are more difficult to recall, especially in terms of intensity and duration. However, these activities, especially sedentary behaviours, have significant links to (adverse) health (Dietz, 1996) and are just as important to assess as moderate to vigorous activities. Activities are easier to recall over a shorter time frame, i.e. previous day rather than previous week, previous week rather than previous month, etc, however seasonal effects may be missed if timeframes are too short when assessing habitual behaviour.

Self-report instruments have shown relatively low correlations with other criterion methods such as calorimetry and accelerometry. Sallis and Saelens (Sallis and

Saelens, 2000) reviewed validation studies carried out in a selection of instruments used in adult populations. Validity correlations reported ranged from 0.14 to 0.36 for methods measuring total habitual or global physical activity, and 0.5 to 0.53 for the Seven-Day Physical Activity Recall (Sallis and Saelens, 2000), depending on the criterion/reference method used.

Commonly used self report tools include the International Physical Activity Questionnaire (IPAQ) (Craig *et al.*, 2003), which is available in long and short form and in different languages; the Baecke Physical Activity Questionnaire (Baecke *et al.*, 1982); the Paffenbarger Physical Activity Questionnaire (No author, 1997); and the Previous Day Physical Activity Recall (Sallis *et al.*, 1993).

Table 1.6 Summary of advantages and disadvantages of physical activity assessment methods

Method	Advantages	Disadvantages
Direct calorimetry	Objective Highly accurate No subject associated bias No attention bias	Not suitable for free-living populations Specialised and expensive facilities/equipment required Does not provide information on type of activity, intensity or duration
Indirect calorimetry – gas exchange	Objective Highly accurate No subject associated bias No attention bias	Not suitable for free-living populations Specialised and expensive facilities/equipment required Does not provide information on type of activity, intensity or duration
Indirect calorimetry – doubly labelled water	Objective Highly accurate Suitable for free-living populations No subject associated bias No attention bias	Very expensive Specialised knowledge, equipment and facilities required Urine samples required – subjects (and researchers) may find unpleasant Does not provide information on type of activity, intensity or duration
Heart rate	Objective Suitable for free-living populations	Decreased accuracy at low intensities (heart rate influenced by other factors) No information on types of activity (no contextual information) May be affected by attention bias
Accelerometry	Objective Relatively inexpensive (although may be beyond budgets of small studies) Suitable for free-living populations	Relies on subject compliance Non-ambulatory activities not well captured (affects measurement of activities with complex movement patterns) Removed while sleeping, and for high impact and water-based activities No information on types of activity May be affected by attention bias
Combined heart rate and accelerometry	Objective High accuracy Worn 24/7 – captures all activity Suitable for free-living populations	Heart rate data can be noisy Individual calibration ideal Reactions to electrodes No information on types of activity (no contextual information) Relatively expensive May be affected by attention bias
Observation	No subject related bias Information on types of activity (contextual information)	Observer related bias Trained observers required Can only observe specific time periods – will not capture full day May be affected by attention bias
Self-report methods	Inexpensive Can be used in large numbers Suitable for use in free-living populations Information on types of activities (contextual information)	Subject related bias Interviewer related bias (for interviewer administered methods) Researcher burden – data coding, data entry (unless automated)

1.3.3. Issues and sources of error in physical activity and dietary assessment

1.3.3.1. Number of days

The number of days to be recorded when measuring absolute measures of behaviour (i.e. not questionnaires that collect data on usual behaviour) is dependent on the assessment method used; the variable of interest; and the research question (e.g. assessment of individual intake; comparison of group means; snap shot versus habitual; usual intakes of short period of time, i.e. a week, versus usual intake over a longer period of time, i.e. a year; etc). The accuracy of a measurement is related to the standard error of the mean (SEM) where:

$$\mathrm{SEM} = (\sigma^2/n + \delta^2/nk)^{1/2}$$

and σ^2 is the between-subject variance, δ^2 the within-subject variance, n the number of subjects, and k the number of days recorded (Nelson *et al.*, 1989). Between-subject and within-subject variance are fixed variables, therefore, the standard error of the mean can only be reduced if n and/or k are increased.

For the assessment of dietary intake at an individual level using food records, Nelson *et al.* calculated the number of days of monitoring required for the estimation of energy, 28 nutrients and the ratio of polyunsaturated to saturated fatty acids, with a reliability greater or equal to 0.9 (Nelson *et al.*, 1989). For adults the number of days required for the measurement of energy and macronutrients (protein, fat and carbohydrate) ranged from 4 days to 6 days for men and 6-days to 8 days for women. For specific fatty acids, 6 to 7-days were required for the measurement of saturated fatty acids; 10 to 12 days for monounsaturated fatty acids; and 15 to 30 days for polyunsaturated acids. For the assessment of a number of micronutrients, large durations were required, such as 20 to 22 days for copper; 18 to 38 days for carotene; and 34 to 35 days for Vitamin B_{12} (Nelson *et al.*, 1989).

For dietary assessment at a group level, if data are collected from a sufficient number of individuals who are representative of the population of interest, single 24 hour recalls or one day diet records can be used to describe average intakes of the group robustly as this is not affected by within person variation (Biro *et al.*, 2002; Thompson and Subar, 2008).

In the field of physical activity assessment, the number of days monitoring required to reflect a person's usual level of physical activity is estimated by calculating the intraclass correlation coefficient (ICC) for a single day of monitoring using the following formula:

$$ICC_s = \sigma^2/(\sigma^2 + \delta^2)$$

where, as above, σ^2 is the between subject variance and δ^2 the within-subject variance. The Spearman-Brown prophency formula is then applied to determine the number of days (N) required to measure usual physical activity to a specified level of reliability (ICC_t), where a value of 0.8 is usually applied.

$$N = [ICC_t/(1 - ICC_t)][(1 - ICC_s)/ICC_s]$$

Studies investigating the number of days required for the assessment of usual and habitual levels of physical activity in adults using accelerometry have found between three and a half and seven days are required (Coleman and Epstein, 1998; Gretebeck and Montoye, 1992; Levin *et al.*, 1999; Matthews *et al.*, 2002). Levin and colleagues also calculated that three completions of four-week physical activity histories and nine completions of concurrent 48-hour physical activity records, are required for reliable estimation of mean annual physical activity (Levin *et al.*, 1999). For determining usual levels at a given point of time, seven concurrent days of monitoring appears to be a sensible choice and will account for any week/weekend day differences, although this may not always be suitable for all study populations and compliance will decrease as number of days required increases (Corder *et al.*, 2007). For estimation of habitual levels, the monitoring of days throughout the year is required (Levin *et al.*, 1999). When measuring dietary behaviour, variation between week and weekend days, and different seasons also needs to be considered.

Ultimately, the number of days recorded will also be influenced by budget, resources available and subject burden. As discussed earlier, methods that are interviewer led require a large amount of staff time, not just for carrying out the interviews but for training beforehand (and possibly refresher training a certain times), coding the data once collected and inputting the data into appropriate nutritional analysis software. If method is too burdensome for subjects, recording will not be completed (or only by a certain type of person) resulting in unrepresentative results. Non-participation in surveys is a major problem, for example in the UK National Diet and Nutrition Survey, response rates had declined by less than 50% in 2000/2001. In an attempt to reduce subject burden and increase response rate, seven day weighed food records have been replaced with four day unweighed food records (Swan *et al.*, 2009). In 2002, the EFCOSUM group aimed to select the most appropriate dietary assessment method for the estimation of acute and usual consumption of populations in a number of different European countries. It was concluded that two non-consecutive 24 hour recalls was the most appropriate method (Biro *et al.*, 2002).

1.3.3.2. Bias in dietary and physical activity assessment

From the description of the current physical activity and dietary assessment methods above, it is clear that bias is a major issue in the assessment of both behaviours. Bias is defined as *'any process at any stage of inference which tends to produce results or conclusions that differ systematically from the truth'* (Sackett, 1979). Many common biases are described by Lissner and colleagues (Lissner *et al.*, 1998) (table 1.7); although this paper addressed dietary assessment, these biases are common to physical activity assessment. Biases are usually associated with self-report methods and lead to the common problem of mis-reporting (both under or over) (Schoeller, 1995). However, objective methods are also affected by bias.

Table 1.7 Examples of bias that may apply to dietary and physical activity assessment (from Lissner *et al.*, 1998)

Type	**Description**	**Comment**
Insensitive-measure bias	When outcome measures are incapable of detecting clinically significant associations	May reflect difficulties in accurate recall, portion size, and generalising to 'usual diet'
Unacceptability bias (type of social desirability bias)	Measurements which embarrass or invade privacy may be systematically refused or evaded	Obese subjects may be particularly prone to this in dietary surveys
Obsequiousness bias (type of social desirability bias)	Subjects may systematically alter responses in the direction they perceive desired by the investigator	Especially relevant in face-to-face dietary interview situations
Underlying-cause bias	Cases may speculate about possible causes for their illness and thus exhibit different recall to previous exposures than control	Important to consider in case-control studies involving dietary exposure with possible nutritional cause
Expectation bias	Observers may systematically err in measuring and recording certain observations so that they concur with previous expectations	May occur in interview situation when unusual diet is reported
Exposure-suspicion bias	A knowledge of the subject's disease may influence both the intensity and outcome of a search for exposure to the putative cause (similar to expectation bias)	Possible in case-control studies when interviewer is not blinded (Also the case in an RCT when interviewer is not blinded)
Attention bias (a type of reactivity bias)	Subjects may systematically alter behaviour when they know they are being observed	Very important when the food-record method is used

Different assessment methods are affected by different biases or degrees of biases. Biases may also interact. Prospective methods, such as filling in a food record or wearing a physical activity monitor, may be more susceptible to attention bias as subjects are more aware that their behaviours are being monitored. Obsequiousness bias may also come into play as behaviours are usually changed in the direction perceived as desirable. The burden involved in some methods may also cause subjects to behave differently (may be considered a reactivity or compliance bias), for example they may choose foods that are easier to weigh in weighed food records. Compliance bias is often referred to in relation to compliance to an intervention. However, all assessment methods rely on subject compliance to some extent, even objective (including criterion) methods (for example, remembering to wear a physical activity monitor, take a urine sample, etc).

Certain types of bias are associated with the investigator (researcher or interviewer or observer), while others are subject related. Investigator associated biases include expectation and exposure-suspicion biases. Investigators may also be influenced by unacceptability bias and will influence insensitivity-measure bias (see below). Subject associated biases include unacceptability, obsequiousness, underlying-cause and attention bias. Subjects will also influence insensitivity-measure bias.

Although insensitivity-measure bias is specific to the assessment method, the degree of insensitivity may be determined by other factors, for example the skills/knowledge of the investigator or subject. Insensitivity-measure bias in recall methods will be influenced by the subject's ability to recall all required details of the behaviour (for example type, portion size, duration and/or intensity), as well as the interviewer's ability to prompt recall effectively. Insensitivity-measure bias in observation studies will also be dependent on the observer's ability to identify and quantify behaviours. Objective, including criterion, methods will also be affected by insensitivity-measure bias as outcomes often rely on assumed relationships.

In addition to the biases described above, memory bias is a major problem in retrospective recall methods. These methods do not actually measure behaviour, but the subject's memory of behaviour (Krall *et al.*, 1988). In retrospective recall methods foods and activities are not only forgotten or omitted, but may be reported that were not consumed or carried out (or carried out for a shorter duration). These events are referred to as 'phantoms' (or 'intrusions' in the U.S. literature). Strategies may be employed to enhance recall, for example, the different stages used in the multiple pass recall dietary interview that review the same information in different ways. A number of these strategies are discussed in chapter two of this thesis.

The accuracy of dietary and physical assessment methods (self-report methods in particular) is also affected by the intelligence, age, gender, emotional state, attention, current behaviours and weight status of the subject, and, to some extent, the interviewer (if applicable). Krall and colleagues summarise how these factors may influence reporting with regard to dietary recall methods (Krall *et al.*, 1988):

- studies have shown that individuals of high intelligence will perform better at memory tasks than those of lower intelligence, and intelligence will influence the understanding of directions for measurement methods;
- children's memories are considered less accurate than adults and there are declines in memory in older adults;
- it is thought that women may recall dietary behaviours more accurately than men, as women have traditionally been more involved in the planning, purchasing and preparation of foods and may pay more attention to dietary intake;
- when recalling past behaviour, recall may be affected by anxiety, boredom or even hunger. The mood of an individual at the time of the behaviour being recalled took place (unless an extreme emotion, such as elation or depression) is thought to be a less important factor;
- the degree of attention that an individual pays to their diet and physical activity levels will also influence recall (most individuals consume foods and drinks and perform activities without much thought and recall may be a challenge);
- recall may be easier for those individuals who follow specific diets for health or social reasons, for example vegetarians, diabetics, individuals on weight loss diets;
- individuals with varied diet may find recall more difficult. Foods and drinks consumed regularly, and those consumed rarely (associated with unique or unusual events) are more easily recalled than those consumed with intermediate frequency.

These influences will also be applicable to physical activity recall, for example recall of structured physical activity may be easier for those taking part in activity for health or training purposes, although recall of general lifestyle activities may still remain a challenge; and individuals with varied physical activity patterns may find recall more difficult.

It is now a fairly well established phenomenon that under-reporting is associated with increased BMI and total body fatness. A number of studies in large representative populations have reported this finding (Briefel *et al.*, 1997; Johansson *et al.*, 1998; Klesges *et al.*, 1995; Price *et al.*, 1997; Pryer *et al.*, 1997; Tooze *et al.*, 2004), although some small studies in specific populations found no such relationship (Horner *et al.*, 2002; Park *et al.*, 2007; Samaras *et al.*, 1999).

Finally, selection bias is also associated with assessment of behaviour in groups and populations. Selection bias occurs at recruitment stages and when incomplete data is collected (and, if applicable, also at follow-up stages due to drop outs). It is often supposed that non-responders have less desirable behaviours than those who take part in dietary surveys or studies.

Strategies can be put it place to minimise some of these biases, for example blinding of subjects and/or interviewers, repeat measures and memory cues/probes. However, it is to be accepted the some biases may be impossible to eliminate and will always need to be considered when interpreting results.

1.3.3.3. Portion sizes

In the absence of weighed portion sizes, a major source of error in subjective dietary assessment is the quantification of the amount of a food item consumed, i.e. the estimation of portion size. Portion size measurement aids are often used as an attempt to improve portion size estimation. Portion size estimation aids include three dimensional aids such as household measures (spoons, glasses, plates, etc), food models (abstract shapes such as wedges, spheres, blocks, etc), food replicas (models of real food) and real food samples, and two dimensional aids such as drawings of foods, abstract shapes or household measures, food photographs and computer images. The ability of an individual to accurately estimate portion sizes and usefulness of portion size estimation aids remains unclear.

In 1997, Cypel and colleagues published a review on the validity of portion size measurement aids (Cypel *et al.*, 1997). At this time only five studies were identified, each investigating different portion size measurement aids and following different protocols and analysis procedures. Various values of agreement, and/or under and over-estimation, were reported. It was concluded that further research was required before guidelines for the use of these aids could be established (Cypel *et al.*, 1997).

Since then a number of other studies have been published investigating the use of portion size measurement aids in adults (Byrd-Bredbenner and Schwartz, 2004; Frobisher and Maxwell, 2003; Godwin *et al.*, 2006; Godwin *et al.*, 2004; Lucas *et al.*, 1995; Nelson *et al.*, 1994; Nelson *et al.*, 1996; Ovaskainen *et al.*, 2007; Robson and Livingstone, 2000; Turconi *et al.*, 2005). Again, these studies investigated a number of different measurement aids, using a variety of protocols and analysis methods. A number of studies found that adults often significantly mis-report (under and over-estimate) portion sizes (Frobisher and Maxwell, 2003; Godwin *et al.*, 2006; Godwin *et al.*, 2004; Turconi *et al.*, 2005), although some foods appeared easier to estimate than others (Godwin *et al.*, 2004; Robson and Livingstone, 2000).

The use of predetermined 'standard' or average portion sizes has also been investigated in a number of studies. Two population studies that substituted estimated portion sizes with average portion sizes in data obtained by food frequency questionnaires found this resulted in misclassification of study subjects and significant differences in outcome variables (Clapp *et al.*, 1991; Welten *et al.*, 2000). However, other similar studies found little difference in resulting outcomes (Paiva *et al.*, 2004) and that using estimated portion sizes added insufficient advantage to outweigh the additional burden and potential data incompleteness (Noethlings *et al.*, 2003). In these studies, absolute intakes are unknown and no criterion or reference methods were used for comparison. Therefore, it is unknown which portion size method results in more accurate results.

In two studies from the same research group, data from semi quantitative food frequency questionnaires were compared with 14-day weighed food records (Haraldsdóttir *et al.*, 1994; Tjønneland *et al.*, 1992). In the first study, correlation coefficients for food group and nutrient comparisons were similar when both estimated and average portion sizes were used, and only small differences were observed when subjects were classified into quintiles of food and nutrient intake (Tjonneland, 1992). The second study found that photographs used to estimate portion sizes were of limited value. Although the majority of subjects (85–95%) selected the most correct photograph or a neighbouring photograph representing the amount of food eaten, regression analyses showed that the relationship between the estimated and the measured portion sizes was relatively weak for most of the foods tested and correlations were only significant for three of the eight foods (Haraldsdóttir *et al.*, 1994). In a study by Kuehneman and colleagues, a number of portion size measurement aids and the assignment of standard portion sizes were used with a food frequency questionnaire designed for parents to report their children's food intake, and compared against weighed values (Kuehneman *et al.*, 1994). The fewest significant differences between the mean weighed amounts of foods were found when using the standard portion size method (Kuehneman *et al.*, 1994). In contrast to the above studies, Nelson *et al.* found that using food photographs, compared with average portion sizes, reduced the misclassification of subjects by nutrient intake when compared with known intakes (Nelson *et al.*, 1996).

It is clear that the process of estimating portion size is extremely complex and that some foods are easier to quantify than others and different portion size measurement aids may be more suitable for certain foods. The ability of portion size measure aids to improve the accuracy of portion sizes remains unclear. In some cases the use of standard portion sizes may be appropriate, especially if subject burden is a concern.

1.3.3.4. Food composition tables and nutritional databases

Once information on the type and amount of food an individual has eaten has been collected, values of the chemical composition of each food/drink consumed are required in order to calculate the nutritional composition of the individual's diet. McCance and Widdowson published the first edition of *The chemical composition of foods* in 1940 (McCance and Widdowson, 1940). The 6th Summary Edition and accompanying supplements is now the latest publication of the McCance and Widdowson's Composition of Foods book series and provides information on the nutrition content of over 1,200 foods (Food Standards Agency, 2002).

Food composition tables and nutrient databases are compiled using a combination of direct and indirect methods (Southgate, 2000). Direct methods involve the compiler sampling and analysing the foods directly, allowing them close control over the quality of the analysis and representativeness of the sample. The indirect method involves obtaining data from other published or unpublished sources.

Even if an exact and precise measurement of food intake has been achieved (i.e. in terms of an exact description of the food item, description of cooking/preparation method, and portion size), food composition tables and nutrient databases provide additional sources of error. The biggest weakness of food composition data is the variation in the composition of foods. Foods are biological materials with natural variability which will be affected by processing, composition of ingredients, packaging and storage, in which minor variations will occur, even in strict controlled conditions (Southgate, 2000). Food composition is also affected by growing/development conditions (for example, soil components, foodstuff for animals, season) and rate of growth (Widdowson and McCance, 1943). Preparation and cooking methods are also a source of additional variation. Fat content in particular is highly variable, especially in meats where fat content can be reduced by trimming or during production (Southgate, 2000).

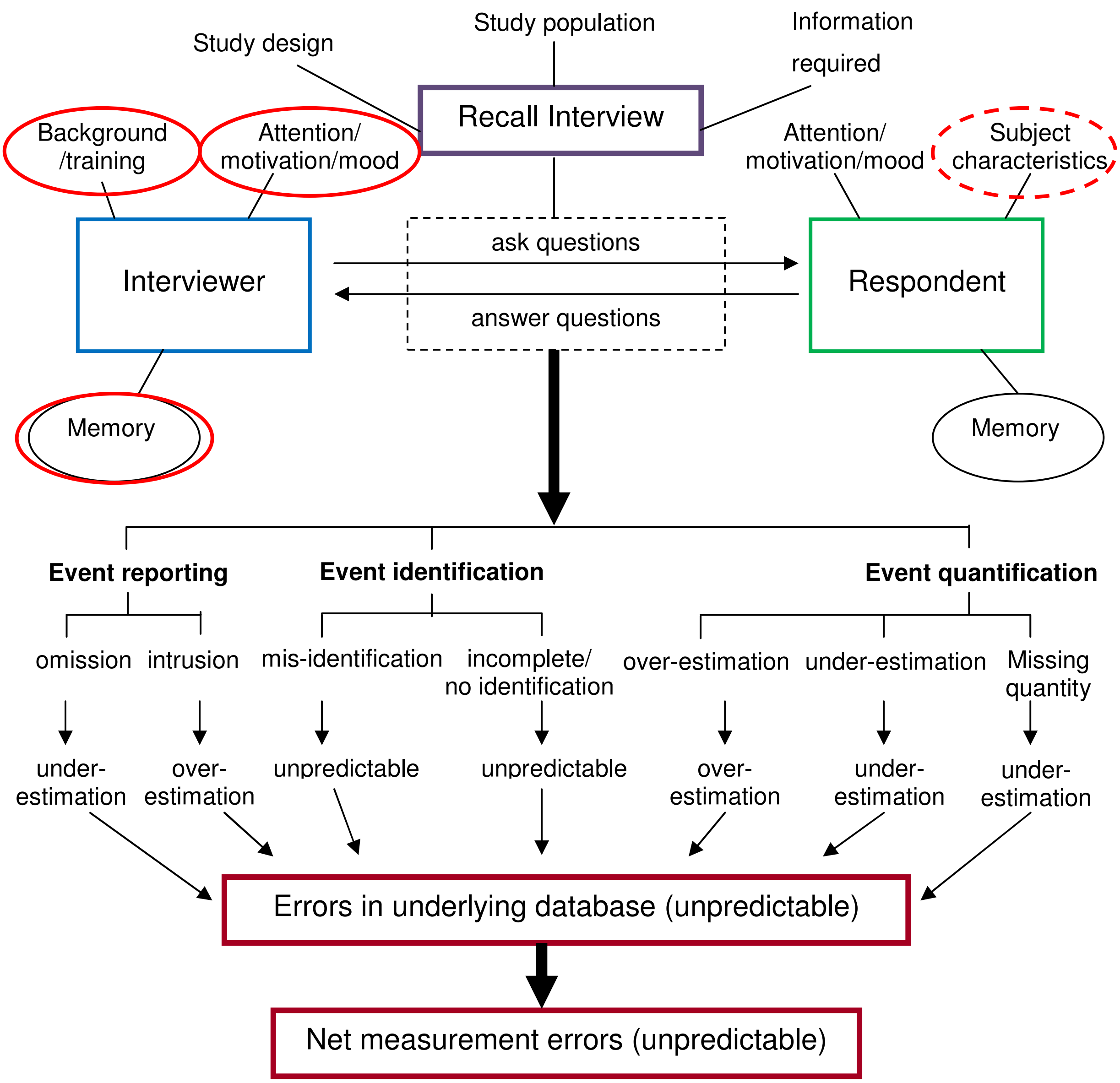
Another major weakness of food composition tables and nutritional databases is their incomplete coverage of the vast number of foods and mixed foods that are available for consumption by the public. Including all foods is practically impossible as this would require enormous resources as well as continuous analysis and re-analysis of foods due to the constant production of new and improved products. Compilers of composition tables and databases have focused on producing data for core foods. In industrialised countries it has been estimated that 500-1000 core foods exist (Southgate, 2000).

When food items are missing, a common strategy is to use values for a biologically similar food or estimate composition using recipe data, if appropriate. This is a source of potential error and will rely on the researcher’s interpretation of a biologically similar food and, if applicable, the assumption that exact recipes were followed.

1.3.4. Summary

Figure 1.7 displays the sources of error involved in an interviewer based recall (applicable to both dietary and physical activity assessment) and demonstrates the issues discussed above. Potential sources of bias that are associated with an interviewer are also highlighted.

Figure 1.7 Sources of error in a interviewer based recall (adapted from Slimani *et al.*, 2000)



1.3.5. Conclusions

The features required by the perfect epidemiological tool for assessing physical activity described by Livingstone and colleagues are as follows (Livingstone *et al.*, 2003) and these features are also applicable to a perfect epidemiological tool for assessing dietary assessment:

- Accurate and precise
- Objective
- Simple to use
- Robust
- Non-reactive
- Cause minimal intrusion into habitual behaviour
- Socially acceptable
- Time-efficient
- Allow continuous and detailed recording of usual behaviour patterns
- Applicable to large population groups.

Unfortunately this tool does not exist. Therefore, the selection of assessment method involves a judgement which depends on the purpose of the assessment, and a balance between accuracy and acceptability. Assessment methods need to be fit for purpose with adequate validity and reliability. Decisions should be made on based on a number of factors, including the purpose of the measurements (the research question), variable(s) of interest, population of interest, sample size, duration of study period, time availability for measurement, budget, and facilities and expertise available.

1.4. Introduction of novel technologies to dietary and physical activity assessment

The focus of this thesis is on computerised, particularly internet-based, approaches to dietary and physical activity assessment. The following section (1.5) discusses the role of the internet in survey and health related research. In section 1.6, examples of existing computerised (including internet-based) dietary and physical activity assessment methods are reported.

In addition to computerised and internet -based approaches, a great deal of novel work is emerging where other new technologies are being used to develop methods of assessment. These advances are not intended to muddy the waters by creating entirely new ways of measuring behaviours. Instead, they aim to build on existing principles, finding more efficient ways of collecting, processing and analyzing data, while maintaining (if not improving) levels of accuracy.

1.4.1. Personal Digital Assistants and mobile phones

The development of Personal Digital Assistants (PDAs) and mobile phones (including smart phones) has opened up a new way of administering assessment methods for diet and physical activity behaviour. The attractiveness of these devices includes their portability and instant accessibility for subjects and that most people now own their own device (Dutton *et al.*, 2009). Methods incorporated with these devices have included diary (Boushey *et al.*, 2009; Saldana *et al.*, 2009) and questionnaire (Bexelius *et al.*, 2010) based applications.

As many of these devices also include camera functions, the use of food imaging along with written or vocal descriptions has also been assessed in the measurement of diet in both adults (Rollo *et al.*, 2009; Six *et al.*, 2009) and adolescents (Boushey *et al.*, 2009; Rollo *et al.*, 2009; Six *et al.*, 2009). These methods appear to be well accepted by both populations, however they do rely on subject compliance to (remember to) take photographs.

1.4.2. Automatic real-time digital photography

Wearable devices that take digital images automatically, capturing whatever is in front of the subject, are emerging in the dietary and physical activity assessment field. The principles behind this method are similar to those previously described using photographs/images. In addition, the automatic nature removes the risk of the subject forgetting to take photographs at key points during the day, thus improving the accuracy of the data collected.

Work being carried out at Oxford University by Dr Charlie Foster is investigating the use of the SenseCam device (Microsoft Research, Cambridge, UK) in measuring domains of physical activity behaviour. The SenseCam is a wearable digital camera that takes photographs automatically and contains a wide-angle (fish-eye) lens that maximizes its field-of-view, ensuring that nearly everything in the wearer's view is captured by the camera (Microsoft Corporation, 2007). Previous applications for the SenseCam have focused on the images it generates being used as prompts to improve autobiographical memory (Berry *et al.*, 2007; Sellen *et al.*, 2007). However, this method is showing considerable potential in the measurement of time spent in travel/journey activities, including both active and sedentary travel (Kelly and Foster, 2010). Further work is planned to investigate the usefulness of this method for the measurement of other domains of activity such as sedentary behaviours and total physical activity (Kelly, 2009).

Automatic image capture has also been investigated for dietary assessment. Studies carried out at the University of California investigated the use of automatic imaging, from a mobile phone worn around the neck, as an aid to recall when coupled with a web-based 24 hour recall (Arab *et al.*, 2009c). Images were captured every 10 seconds, an appropriate interval to capture most eating occasions (Arab *et al.*, 2009b), and transferred wirelessly to a web-site where they were processed and displayed during the 24 hour recall. Only 7% of participants reported that the images were unhelpful during the recall. This work identified practical issues involved in using this method both from a researcher and subject perspective.

A recent paper by Sun and colleagues also describes a wearable automatic image capture system for dietary assessment (Sun *et al.*, 2010). This device stores images on an 8-GB memory card, which are transferred to a registered dietitian's computer at regular intervals where they can be processed. This system also contains privacy protection features; data on the memory card are scrambled after it is transferred to a computer for processing, and images are scanned for human faces which are then blurred. In addition to the camera, the device can also contain other sensors and data processing/storage components such as microphones, skin surface electrodes, accelerometers and global positioning systems (GPS), which can be used for a number of applications including physical activity measurement.

1.4.3. Automatic food identification and volume computation using digital images

When images are used for dietary assessment, the images need to be converted into something meaningful (i.e. nutritional values) and this is usually done by a suitably trained researcher (nutritionist or dietitian), along with the notes recorded by the subject. Although this process can introduce some researcher bias, this method is relatively accurate. However, it does require suitably trained researchers which can be costly. The use of technology that can automatically identify foods and portion sizes from digital images offers a significant solution to this problem. The technologies and techniques involved in these processes are described by Boushey and colleges (Boushey *et al.*, 2009; Mariappan *et al.*, 2009; Woo *et al.*, 2010; Zhu *et al.*, 2010) and Weiss and colleagues (Weiss *et al.*, 2010). Automatic portion size detection techniques have also been incorporated into the device as described by Sun et al. (Sun *et al.*, 2010).

There are many challenges associated with these processes including clarity of the image taken; resolution size of the image and speed of data transfer; use of a suitable fiducial marker (calibration object for portion size estimation); number of images required; and the detection of portion sizes in foods that do not have easily identified shapes (non spherical or prismatic) (Boushey *et al.*, 2009; Weiss *et al.*, 2010; Woo *et al.*, 2010). Time is also required to develop a comprehensive database of foods that will allow automatic detection (Boushey *et al.*, 2009).

Although this is a very promising approach, the technology requires significant further development before it can be used for measurement of total dietary intakes of 'real world', free-living populations.

Technology assisted dietary and physical activity assessment may offer solutions for many issues associated with the methods currently used (pen/paper and interviewer). In addition, these approaches appear to be well accepted by adults (Six *et al.*, 2009) and adolescents (considered the most difficult population to engage with, and are also the next generation of adults) (Boushey *et al.*, 2009).

Although the incorporation of some of the technologies described above into assessment methods may not be available at present, approaches using PDA and mobile phone technologies and automatic image capture (where images are either interpreted by suitable personnel or used as a prompt for recall) are readily available. However, these methods do not offer a perfect solution to the problem of diet and physical activity assessment in that they all, in part, often rely on subject compliance, just as traditional methods do. Importantly, these technologies may remain beyond the capabilities and budgets of some study and/or evaluation research due to their relative high cost.

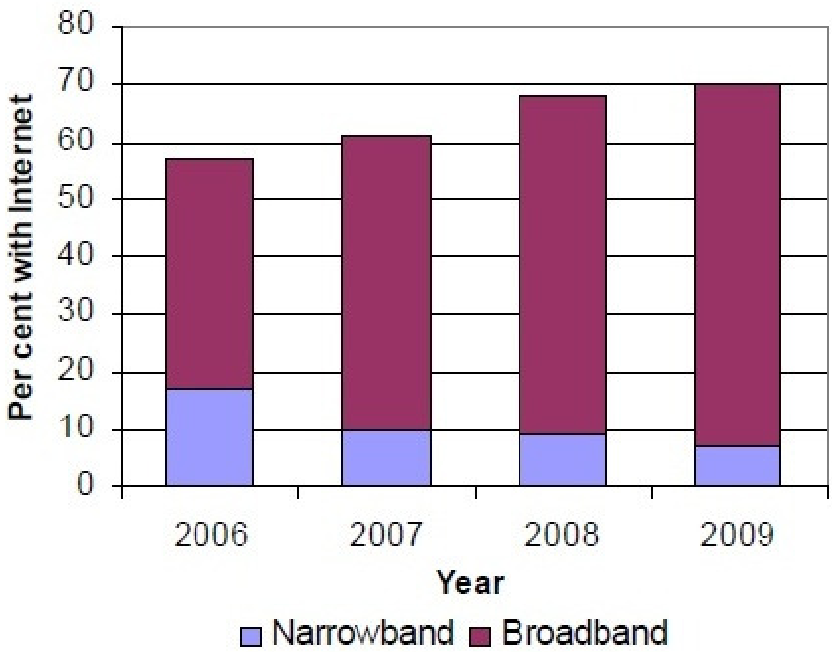
1.5. Internet based research

The internet is used for a whole range of activities, from basic communication with friends/family/work colleagues through email and social networking, to online banking and shopping, to sources of entertainment such as web-radio/TV and film/music downloads, to learning and training, and to even finding love and friendship. The perceived power of the internet to reach and influence large numbers of the population is highlighted by the increasing investment in web-based advertisement: in the first half of 2009, internet advertising, despite the recession, overtook TV advertising for the first time, growing by 4.6% to £1,752.1m (Internet Advertising Bureau, 2009). It is not just marketing companies taking advantage of the opportunities that the internet provides, the application of e-health technology continues to grow, using the internet not only as a means of providing health information but as a vehicle for health-related interventions and initiatives, assessment and feedback, aimed at changing health behaviours.

1.5.1. Internet use in the UK

Availability, accessibility, connection quality and use of the internet in the UK continues to increase. Recent data from the Office for National Statistics show

Figure 1.8 Households with access to the internet and broadband in the UK, 2006-2009 (Office for National Statistics, 2009)



that in 2009, 18.3 million (70%) households in the UK had internet access compared with 14.3 million (57%) in 2006, and of those houses with internet access, 90% had broadband connection in 2009, compared with 69% in 1996 (figure 1.8). Approximately 76% of the UK adult population had accessed the internet in the last 3 months, compared with 67% in 2007. From the 2009 data, 73% of those who had accessed the internet within the last 3 months were frequent users (used the internet every, or almost every, day).

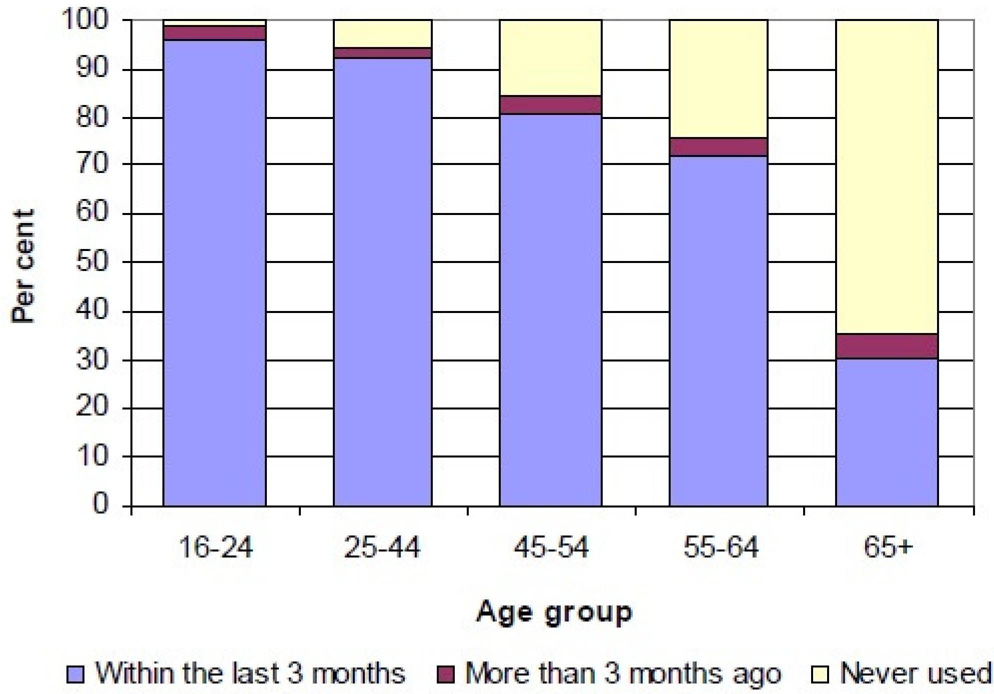
Digital divides

Despite the continued increase in internet use overall, there are still certain groups that have access to and/or use the internet more than others.

Age and life stage

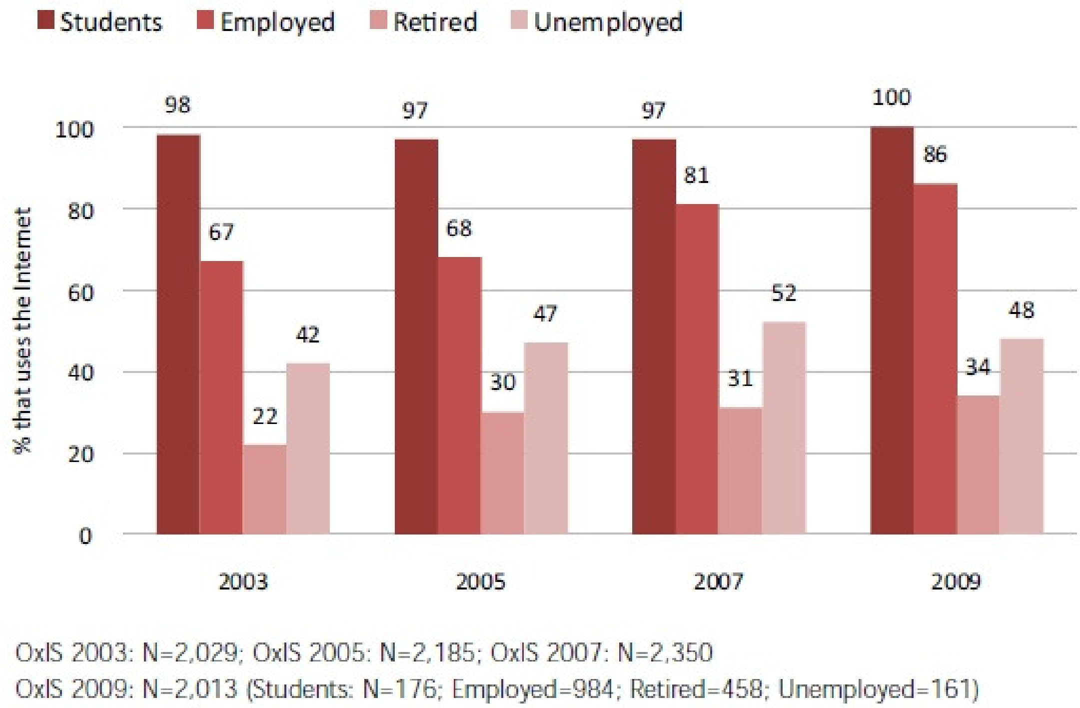
The Office for National Statistics 2009 data show that younger groups have the highest level of usage (figure 1.9), however, the largest increase, proportionally, of those accessing the internet from 2007 to 2009 was in the 65+ age group.

Figure 1.9 Individuals use of the internet in 2009 in the UK, by age (Office for National Statistics, 2009)



Results from the Oxford Internet Survey, *The Internet in Britain 2009* (Dutton *et al.*, 2009), show that life stage remained a main factor associated with internet use from 2003 to 2009 (figure 1.10). Students continue to be the highest users. Use by the employed increased considerably from 2005 to 2007, with a further smaller increase in 2009. After an increase from 2003 to 2005, internet use by those retired has remained fairly constant between 2005 and 2009. The number of users who are unemployed has changed little from 2003 to 2009.

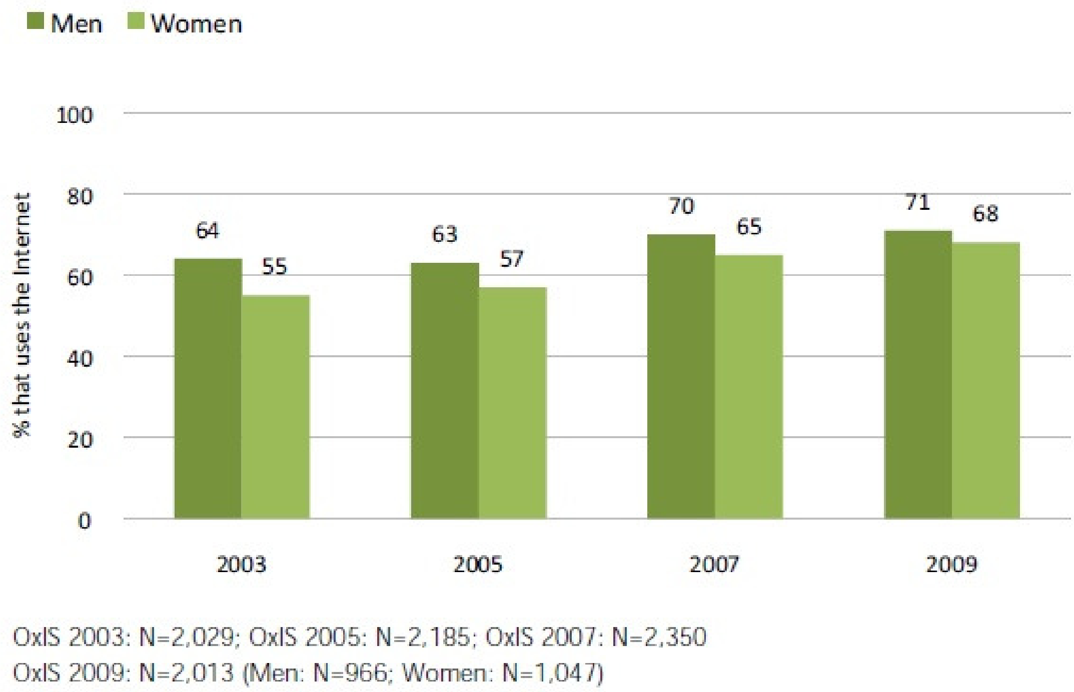
Figure 1.10 Internet use in the UK, by life stage, 2003 to 2009 (Dutton *et al.*, 2009)



<u>Gender</u>

Men continue to use the internet more than women (Dutton *et al.*, 2009; Office for National Statistics, 2009), however the divide has decreased between 2003 and 2009 (Dutton *et al.*, 2009) (figure 1.11)

Figure 1.11 Internet use in the UK, by gender, 2003 to 2009 (Dutton *et al.*, 2009)



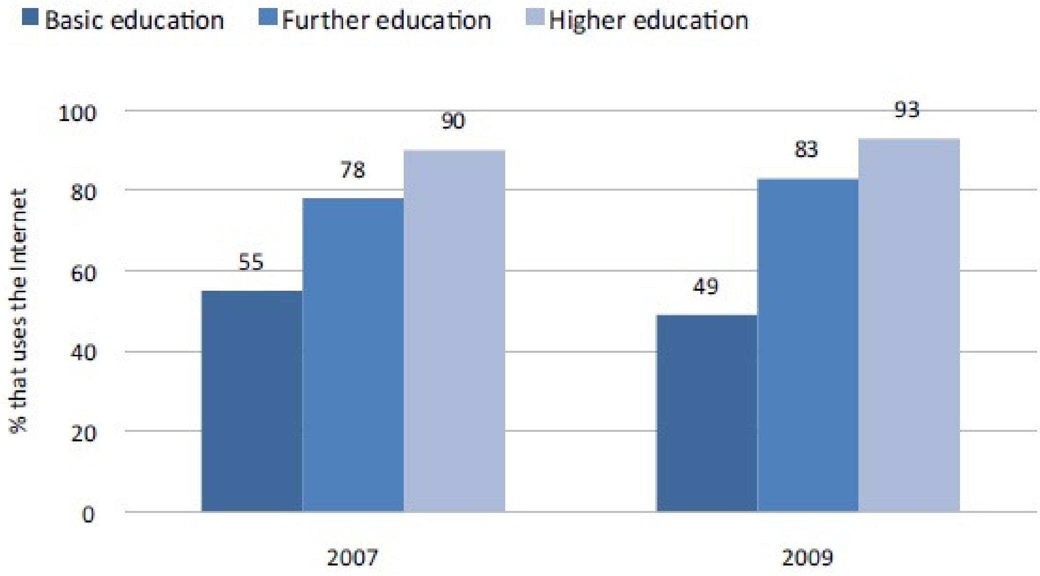
Location

In 2009, London had the highest number of households with internet access (80%) (Office for National Statistics, 2009). The percentage of households in the North East of England with internet access was 66%, lower than the UK average of 70% (only Yorkshire and Humber, and Scotland had lower percentages of 64% and 62% respectively). However, the North East had the highest increase in the percentage of households with internet access between 2007 and 2009, compared with all other regions in England. This was also higher than the increase observed in Wales and Scotland.

Education, employment and socio-economic status

Education and employment status also appear to be strong predictors of internet use. An estimated 95% of adults who had a degree or equivalent qualification had internet access in their home, compared with 52% of adults who had no formal qualifications (Office for National Statistics, 2009). Internet use was also highest in those with higher education in 2007 and 2009 (figure 1.12) (Dutton *et al.*, 2009). Internet use of those with basic education decreased from 2007 to 2009, widening the gap between them and those with higher education.

Figure 1.12 Internet use in the UK, by education level, 2007 & 2009 (Dutton *et al.*, 2009)



OxIS 2007: N=2,350; OxIS 2009: N=2,013 (Basic: N=901; Further: N=510; Higher: N=360)
Note: Students were excluded.

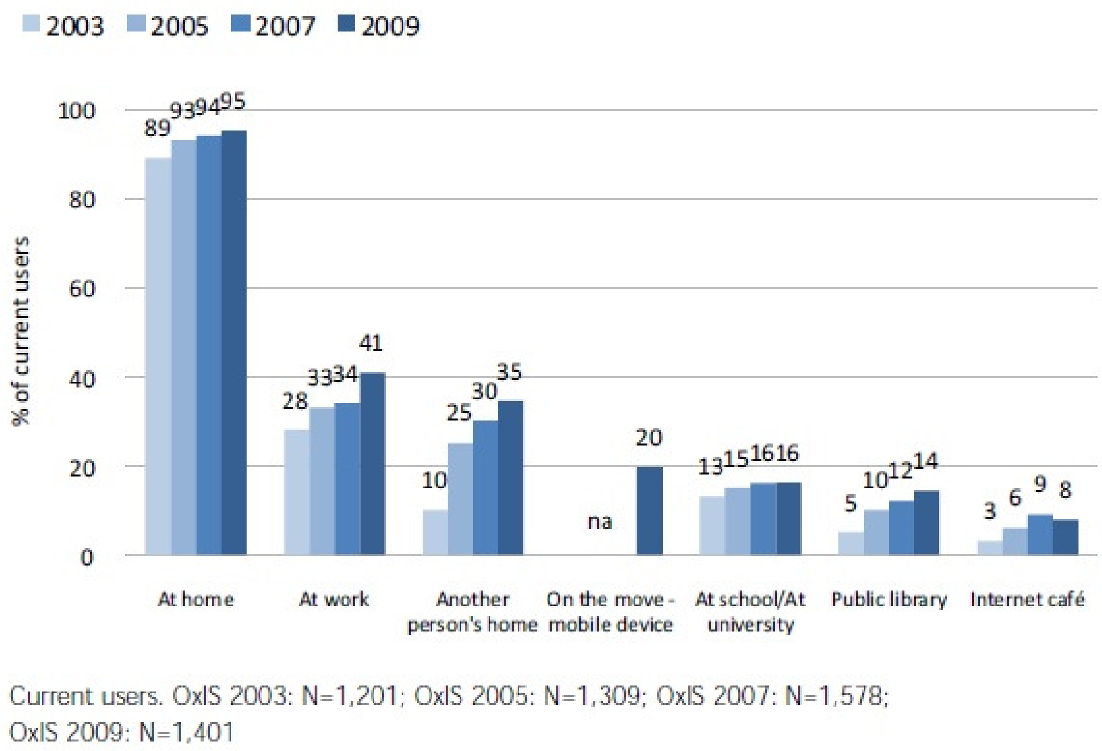
Findings from Ofcom's Media Literacy Audit also suggest that there is a marked difference between internet access in the home by socio-economic group (ABC1 86% compared to C2DE 63%) (Ofcom, 2008). Children in the C2DE are more likely to access the internet outside the home. This access was mainly at school but also at friend's houses with internet access. Findings from the Oxford Internet Survey also show that people of higher grades (AB) are nearly twice as likely to use the internet than those in the lowest social grade (DE) (88% vs. 46%) (Dutton *et al.*, 2009).

Access outside of the home

Figure 1.13 shows locations of internet use. Although most internet use is carried out at home, use in locations outside the home has also continued to increase from 2003 to 2009 (Dutton *et al.*, 2009). These locations include use at work, university/school and public libraries.

Efforts to increase internet access and use in more deprived groups include the provision of UK online centres, a scheme set up by the government in 2000. The aim of these centres is to provide access to ICT, along with training, to 'help improve individual lives, strengthen communities and achieve social inclusion'. UK online centres can be found on high streets, in libraries, internet cafés and community centres, as well as some mobile centres on buses. There are 3,500 member centres, with centres in 84% of deprived wards. An estimated 2 million people use UK online centres each year (UK Online Centres, 2009).

Figure 1.13 Locations of internet use in the UK, 2003 to 2009 (Dutton *et al.*, 2009)



Use of internet for seeking out health information

In 2009, seeking health related information was the joint 7th most popular activity, along with listening to web radio or watching web TV, carried out on the internet (42% of all adults who accessed the internet in the last 3 months). This was an increase from 34% in 2008 (Office for National Statistics, 2009). Results from the Oxford Internet Survey (Dutton *et al.*, 2009) also show that in 2009 68% of those surveyed had used the internet to search for health related information, compared with 37% in 2005.

Data suggests that the internet is also used differently by different groups. Women tend to use the internet to seek health related information more than men: 48% vs 37% of adults who had accessed the internet in the last 3 months (Office for National Statistics, 2009) and 73% vs 63% of all users surveyed (Dutton *et al.*, 2009). Results from the Oxford Internet Survey also show that health information was sought more frequently by those who were employed and retired (both 70% of all users surveyed), than by students (60%) (Dutton *et al.*, 2009).

1.5.2. Advantages of internet based research

Time and money

One of the main advantages of internet based research is the speed in which experiments and/or surveys can be delivered to subjects in any geographical location. Data can also be stored and, potentially, analysed automatically. This all results in huge savings through the elimination of costs involved in postage, equipment, paper, lab space, travel, telephone and, possibly most significantly, researcher time required for experiment delivery, and data collection, coding, entry, processing and analysis.

Large samples

The popularity of the internet seems to indicate that using this medium to advertise studies and recruit participants will theoretically reach a large proportion of the population, with the potential to recruit large numbers in a short space of time, offering the associated advantages of increased power of statistical tests; the ability to perform subgroup analysis; and to fit statistical models cleanly.

Reduced burden and embarrassment

Another huge advantage in using the internet for research is the convenience for participants who are able to take part without the burden of travelling to a research centre, or even finding a post box, and, in many cases, in the comfort of their own home. In some cases, the relative anonymity of answering to a computer may be more appealing, especially for issues that could cause social embarrassment. This may also result in more ‘truthful’ reporting, for example a participant may be more likely to report less socially accepted behaviours such as high fat dietary intake, smoking, unprotected sex etc, in an internet-based survey, than in a researcher-led interview or distributed survey. In studies investigating social influences of internet use, it has been found that people felt better able to express their ‘true’ selves when communicating over the internet compared with face-to-face with previously unknown individuals (Bargh, 2002).

1.5.3. Disadvantages and challenges of internet based research

Recruitment and retention

Despite the popularity of the internet and its wide reaching potential for research, it cannot be assumed that this will always translate into a higher response rate (Leece *et al.*, 2004). Studies investigating response rates to internet-based and mail ‘paper-pencil’ surveys have found lower response rates when using an internet survey (Leece *et al.*, 2004); equivalent response rates for both method (Kaplowitz *et al.*, 2004; Ritter *et al.*, 2004); and higher response rates (Lonsdale *et al.*, 2006). In the studies reporting equivalent or higher response rates, the authors did conclude that, overall, lower costs and effort per response were achieved when using the internet-based surveys.

How participants are invited to take part in an internet-based survey may also have an effect on initial response rate. It is thought that participants recruited via the internet, or by email, are more likely to respond to an internet-based survey than the general population as they are assumed to be ‘internet-savvy’ (Schonlau, 2004). In the way that recruiting participants via the internet to complete a paper-based survey may result in a reduced response rate due to differences between recruiting and responding modes (Schonlau, 2004), it may also be theorised that using non-internet methods (mail invitations; posters; media advertising) to recruit participants to an internet-based intervention or survey may not be an effective strategy, but this is yet to be proven.

Recruitment rates (number of participants who completed the recruitment process: consent procedure, baseline data collection) of a number of health related internet-based interventions, where known numbers of participants were invited to take part, range from 0.24% (Koo and Skinner, 2005), 8.9% (Stopponi *et al.*, 2009), 10% (Ware *et al.*, 2008b), 33% (Block *et al.*, 2004), and between 0.7% and 10% in different groups invited in a study by Glasgow and colleagues (Glasgow *et al.*, 2007).

Low retention rates may be one of the greatest problems in internet-based research. Retention rates in published studies have ranged from less than 10% using a web-program more than once (Verheijden *et al.*, 2007); 48% providing 12 month follow-up data (Glasgow *et al.*, 2007); to 74% providing 12 week follow-up data (Ware *et al.*, 2008b). Low retention rates may be due to the way that internet-based studies differ from studies in face-to-face settings, in that "*Web participants are free of any social pressure or embarrassment. They simply click a button to quit the study and do something else*" (Birnbaum, 2004, p817)

In a study by O'Neil and Penrod (O'Neil and Penrod, 2001), drop-out rates were monitored over the study carried out over four web-pages (page 1 – introduction and general instructions; page 2 – consent form with some additional questions; page 3 – research materials and questions relating to these; and page 4 – demographic questions). Of 791 participants who accessed the first page, 409 reached the second page, 282 the third page and 193 (22.4% of the beginning sample) completed the study. The study found that requiring participants to enter email addresses increased drop out from page one to two, however those not asked for an email address were more likely to drop out between pages two and three. The authors suggested that the exercise of asking for the email address primarily affected those participants who were low in motivation, resulting in them dropping out of the study. The second page contained a large amount of text and was where people with low motivation dropped out when an email address was not previously asked for. Therefore, asking for an email address simply speeded up the drop out process.

This study suggests that complicated processes, involving navigation through a number of web-pages, may increase drop-out rates, especially in those individuals with low motivation. The study also found that only 16 of 197 participants entered email addresses that appeared to be invalid; taking part on the weekend decreased drop out from page one to two; and no significant effect of offering payment through a lottery was observed (O'Neil and Penrod, 2001).

A small feasibility study which investigated the feasibility of the LinkMedica-Heart program carried out by Anhøj & Jensen (Anhøj and Jensen, 2004) also provides some useful learning. The LinkMedica-Heart website gave personalised advice and support to individuals, through email messages, based on results of a diet questionnaire (FFQ design) and activity questionnaire, and the intensity of program selected by the participant. The study showed that no participants completed the program and that personal questionnaires were updated no more than a few times, if ever. Feedback from GP's was that, in their opinion, the program was too complicated but also that program's interaction with patients was too infrequent and meagre.

One main issue identified by the study was the need for a reliable assessment method and the advice given. A large amount of effort was used to create the text advice given to patients. However, some patients felt that the advice they received was not suitable or agreed with their own expectations (Anhøj and Jensen, 2004). The preference for the questionnaire of the participants was varied and conflicting, with some wanting to complete every day and some preferring a less demanding program. The authors concluded that the perfect program is one that can adapt to the patient's preference (Anhøj and Jensen, 2004). The study found a positive attitude to web-based programs however the program did not address the need in the current state. The patients identified that changes in lifestyle do not come from using a computer based program; it is a tool and could never replace a health care professional (Anhøj and Jensen, 2004).

As with public health interventions in other settings, it is unclear what strategies are effective for increasing recruitment and retention to internet-based studies. Personalised mailings and staggered incentives (giving incentives of increasing value at different stages of an intervention) show some promise (Alexander *et al.*, 2008; Glasgow *et al.*, 2007).

Multiple submissions

One problem that causes concern for researchers using internet-based studies is the potential of the same participants making multiple and/or ‘fake’ entires, especially in studies with monetary incentives (Eysenbach and Wyatt, 2002), which can cause a serious threat to the validity of the data collected.

A number of strategies can be put in place to prevent multiple submissions (Birnbaum, 2004; Eysenbach and Wyatt, 2002; Eysenbach, 2004). There is a consensus among web researchers that this issue is not a major problem (Birnbaum, 2004), with an estimation of repeat participation below 3% in most internet-based studies (Reips, 2002), however it may be prudent to put a protocol in place, taking into account creative measures that some participants may take to benefit from incentives offered. A cautionary tale is reported by Konstan and colleagues (Konstan *et al.*, 2005) where, in an internet survey offering $20, one participant was responsible for 65 of a total of 119 repeated completions identified, through using different computers and providing different email addresses and bank details each time.

Verification of participants’ attributes

Whether data are collected via an internet or a paper-based questionnaire, the verification of participants’ attributes is difficult to determine. This limitation will become an issue for studies that target specific populations, for example those targeted at a specific age group, geographical location, gender or ethnic group. Some procedures are available to verify certain age groups (for example, credit card information to verify age in adult studies) and geographical location (Koo and Skinner, 2005), but these are coupled with privacy issues and cost implications.

Sampling bias

Sampling bias is a problem in survey research as, no matter how many or who are invited to take part, respondents are ultimately those who ‘choose’ to complete the survey, resulting in a self-selected sample. Self-selection bias occurs as those who choose to respond to surveys tend to do so because they are affected by and/or interested in what the survey is asking about, or they are attracted to any incentives on offer (Eysenbach and Wyatt, 2002). In web-based research, additional bias will be added if the target population is unrepresented by the internet population (we know from earlier on in this section that some groups use the internet less than others).

"Netiquette"

Another important consideration, especially when using the internet for study recruitment, is the use of channels in an appropriate manner. A successful method of recruitment may be through email invitation; however care must be taken to ensure that these invitations are not considered 'spam'. It can also be considered bad manners to cross-post out-of-context messages in discussion forums (Koo and Skinner, 2005). Both behaviours could lead to the sender being 'flamed' (angry messages sent to entire mailing lists in response to email invitation; angry and hostile responses to an out-of-context post in a discussion forum), resulting in damaged reputation (Birnbaum, 2004; Koo and Skinner, 2005). A recommended strategy to avoid going down in 'flames' is to contact individuals through, and with the support of, relevant organisations with internet presence (Birnbaum, 2004).

1.5.4. Agreement between computer-based and paper-based instruments

It cannot be assumed a computerised version of a validated paper based self-report instrument will yield the same responses, as the psychometric properties of each method will be different (Ritter *et al.*, 2004) and it is important that computer-based instruments are evaluated in terms of reliability and validity. A number of studies have found equivalent outcomes using computer-based questionnaires when compared with the paper version (Buchanan and Smith, 1999; Buchanan, 2003; Davis, 1999; Fouladi *et al.*, 2002; Lonsdale *et al.*, 2006; Miller *et al.*, 2002; Ritter *et al.*, 2004).

1.5.5. Conclusions

Although there are a number of limitations associated with internet-based research, many investigators consider the advantages in experimental power, low cost, and convenience of testing via the internet to outweigh any disadvantages.

1.6. Computerised and internet based approaches to diet and physical activity assessment

Computerised (including internet-based) approaches have been applied to concurrent, long-term (frequency) recall and short-term recall methods of dietary and physical activity assessment. The advantages of a computerised approach include standardised data collection; instant data entry; automatic checks to ensure responses are complete; and visual and aural cues to stimulate recall (Kohlmeier *et al.*, 1997). The addition of an internet setting brings the advantage of administration to large numbers over a short space of time at little cost. For the purpose of this thesis, the benefits of using a computerised system as a substitute for an interviewer are of particular interest. These include the ability to conduct in-depth interviews without the cost of providing interviewers, and also the elimination of any interviewer-associated biases.

1.6.1. Current computerised and internet based dietary and physical activity assessment tools

Over recent years a number of computerised dietary and physical activity assessment tools have been developed, and in more recent years these have incorporated access via the internet. A summary of a number of programs are reported in Tables 1.8 to 1.10. This is not an exhaustive list but these programs are believed to be the most current and relevant. For the purpose of this thesis, programs based on long-term recall or history methods are not described. A number of commercial programs have been reported in the literature (Lee *et al.*, 1995). However, only research-based programs that are exclusively designed for measurement are described here.

A number of these tools have been used in large scale studies or for national surveillance. EPIC-SOFT was designed for use in the European Prospective Investigation into Cancer and Nutrition (EPIC) that includes 24 European countries (Slimani *et al.*, 1999); YANA-C was developed as part of the Healthy Lifestyle in Europe by Nutrition in Adolescents (HELENA) Study (Vereecken *et al.*, 2008); LEDDAS© was used to collect dietary data in the 1997 New Zealand National Nutrition Survey (Parnell *et al.*, 2001; Quigley and Watts, 1997); and the USDA

Automated Multiple Pass Methods has been used since 2002 to collect dietary recalls in What We Eat in America (WWEIA), the dietary interview component of the National Health and Nutrition Examination Survey (NHANES) (Moshfegh *et al.*, 2008).

Dietary assessment tools

Most of the programs reported below measure dietary intake (n=11) (table 1.8). Six of the programs are designed for use in adult populations and five in children and/or adolescents. Four of the programs are interviewer administered (USDA Automated Multiple Pass; EPIC-SOFT; LEDDAS©; IPSAS). All of the programs follow a multiple pass or 'stage' approach to enhance recall, with the exception of IPSAS (that was primarily designed as a portion size estimated aid which is now used in SCRAN24), and all use a detailed portion size estimation systems. Three programs were administered in more than one language (IMM; EPIC-SOFT; YANA-C). One program (IMM) demonstrated the strength of a computerised system for use in low-income and literacy groups (Zoellner *et al.*, 2005).

Physical activity assessment tools

There appears to only be a few computerised programs that have been developed for the short-term measurement of physical activity, all of which are designed for use in children or adolescents (table 1.9).

Combined dietary and physical activity assessment tools

There are currently very few tools designed to collect data on diet and physical activity simultaneously (table 1.10). To my knowledge, only three programs of this type have been developed and validated, two of these by colleagues at Durham University and Teesside University (peas@tees and SNAP™). All three of these programs are designed for use with children. To the author's knowledge, no programs designed for the simultaneous assessment of diet and physical activity behaviours of adult populations have been developed and validated.

Table 1.8 Summary of existing computerised and internet-based dietary and assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
USDA Automated Multiple Pass Method (Bliss, 2004; Dwyer *et al.*, 2003; Moshfegh *et al.*, 2008)	US	Adults	Computerised version of the USA Department of Agriculture (USDA) Multiple Pass method Interviewer administered Navigates interviewer through recall, standardized questions and response options for different items Used in conjunction with portion size estimation aids.	Macro- & micro-nutrient	Not reported	No	Validation against doubly labelled water Energy intake underreported by 11% 78% of men and 74% of women were classified as acceptable energy reporters Underreported highest in obese subjects
Automated Self-Administered 24-hour recall (ASA24) (Subar *et al.*, 2009; Subar *et al.*, 2010)	US	Adults	Modelled on USDA Automated Multiple Pass Method. Self administered Animated characters, audio cues Pictures of portion size choices	Macro- & micro-nutrient	Not reported	Yes	No overall validation reported Portion size method validated against known weights

Table 1.8 (continued) Summary of existing computerised and internet-based dietary assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
EPIC-SOFT (Crispim *et al.*, 2009; Slimani *et al.*, 1999; Slimani *et al.*, 2000; Slimani and Valsta, 2002)	Europe	Adults	Interviewer administrated Automatic coding of food/drinks and recipes (with option to enter new items if required) Standardised procedure for all countries 4 stages: General information; quick list; detailed description; quality control Portion sizes methods: Photos/models, household measurements, standard units, standard portions, gram/volume method and 'unknown' method Continually updated, centrally maintained	Macro & micro-nutrient	30-35 minutes (additional time required if new data is added)	No	Validated against biomarkers in five countries. Underestimation of potassium in all counties except Czech Republic (overestimation) Ranking of fish intake between countries same as ranking using biomarkers
LEDDAS© (Parnell *et al.*, 2001; Quigley and Watts, 1997)	New Zealand	Adults	Used in 1997 New Zealand Nutrition Survey Interviewer administrated 24 hour recall Direct data entry (no coding); questions answered sequentially ensuring complete dataset; standardised questions; automatic prompts to next appropriate question 3 stages: Quick list; detailed description; review	Macro & micro-nutrient	Not stated	No	No validation work reported

Table 1.8 (continued) Summary of existing computerised and internet-based dietary assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
Bilingual Interactive Multimedia (IMM) Dietary Assessment Tool (Zoellner *et al.*, 2005)	US	Adults	Based on multiple pass dietary recall Self administered English and Spanish Audio instructions included Touch screen computer used Choice of 4 portion sizes – interactively shrink and grow	Macro & micro-nutrient	16.5 minutes (including 4 minutes audio instructions)	No	Method comparison against interview-administered 24-hour recall Only vitamin C intake higher in IMM recall. Validity correlation (unadjusted) approximately 0.6 between IMM and interview Standardised portion sizes resulted in significant differences for six nutrients and decreased correlations.
Young Children's Nutrition Assessment on the Web (YCNA-W) (Vereecken *et al.*, 2010; Vereecken *et al.*, 2009)	Europe	Pre-school children	Completed by parents Day divided into 24 potential eating occasions linked to hours of day Portion size photographs, measurement units Extra questions to probe for extra food items, i.e. mayonnaise with French fries, butter on bread, drinks with meals	Macro & micro-nutrient	Not reported	Yes	Comparison against food record No substantial differences between methods for energy intake, nutrients or food groups, except water (but possibly due to difference in portion size measurement)

Table 1.8 (continued) Summary of existing computerised and internet-based dietary assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
Young Adolescents' Nutrition Assessment on Computer (YANA-C) (Vereecken *et al*., 2005; Vereecken *et al*., 2008)	Europe	Adolescents (11+ years)	Self administered Structured according to six meal occasions: breakfast, morning snack, midday meal, afternoon snack, evening meal and evening snack Portion size photographs, measurement units Extra questions to probe for extra food items, i.e. mayonnaise with French fries, butter on bread, drinks with meals Review after all meals completed	Macro & micro-nutrient Food groups	Not reported	No	Method comparison (1-day food diary and 24 hour recall) Agreement at food group level: average 90% (food record), 89% (recall). Correlations for energy and nutrient intake 0.44 to 0.79 (food diary); and 0.44 to 0.86 (24 hour recall). Overestimations of energy and most nutrients (food record), no significant difference for all items except fibre (recall). Self-administered lower energy and fat intake compared with interviewer administered High correlations between administration modes (0.86 to 0.91)
Food Intake Recording Software System (FIRSSt) (Baranowski *et al*., 2002)	US	Children	Based on multiple pass dietary recall Self administered Portion size method: users identify type, shape and size of container. Mounds used to report portions on a plate Review process after each meal is completed	Food item/ group	Not reported	No	Comparison against lunch observation 46% match, 24% intrusion and 30% omission rates Less accurate than dietician conducted 24 hour recall

Table 1.8 (continued) Summary of existing computerised and internet-based dietary assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
Interactive portion size assessment system (IPSAS) (Adamson, 2009; Foster *et al*., 2008; Foster *et al*., 2009)	UK	Children (pre-school to aged 16 years)	Designed as portion size aid tool Interviewer administered 2050 images of food Food as served and leftovers estimated All food photographs linked and compatible with food composition codes	Macro- & micro-nutrient	Not stated	No	Method comparison against known weights of foods (served and consumed) 4% underestimation of weight of food served 13% overestimation of weight of food consumed Percentage error ranged from -21.5% to 26.8% for nutrient estimation (percentage error depended on age group)
School Children's Recall - Assessment of Nutrition (SCRAN) 24 (Adamson, 2009; Hawkins, 2009)	UK	Children (aged 11-16 years)	Based on multiple pass dietary recall Self administered Quick list Foods in quick list confirmed as known to system or prompted for further detail e.g. sandwich Automated prompting "passes" for missed food and drink Estimation of amount served and leftover (incorporates portion size method developed in IPSAS) Time assigned to eating occasion using a time line Automatic analysis of data	Macro- & micro-nutrient	Not stated	Yes	Pilot work in progress

Table 1.8 (continued) Summary of existing computerised and internet-based dietary assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
DietDay (Arab *et al.*, 2009a)	US	Adults	Based on multiple pass dietary recall Food-image, meal-based cognitive support Portion sizes change on plate Immediate feedback	Macro- & micro-nutrient	Not reported	Yes	Validated against doubly labelled water Correlations (2 days): 0.07 to 0.44; (7 days) 0.25 to 0.56. Agreement greatest among youngest age group (<30 years) Mean energy difference = 2465 vs. 2433

Table 1.9 Summary of existing computerised and internet-based physical activity assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
Computerised physical activity recall (CAR) (McMurray *et al.*, 1998)	US	Children/ adolescent	Self administered Sedentary and physical activities measured (duration ≥15 minutes) Segmented day Activities categorised Intensity not asked Automatic checks for complete data	Total energy expenditure Activity energy expenditure Minutes activity ≥3 METs	Not reported	No	Method comparison against accelerometry Validity correlation = 0.51 CAR estimated total energy expenditure significantly lower (8.14 vs. 6.6 MJ, $p<0.001$) No significant difference in activity energy expenditure CAR estimated minutes activities ≥3 METs significantly higher (50.4 vs 76.7, $p = 0.02$) Test-retest correlation = 0.82
Computer Delivered Physical Activity Questionnaire (CDPAQ) (Ridley *et al.*, 2001)	Australia	Children	Self administered Segmented day Sport and incidental activity, measured Multimedia effects (images, photo, video, sound, videos demonstrate intensity levels) Timeline slider Automatic checks for unrealistic data	Total METs, Total minutes of physical activity Minutes MVPA	Not reported	No	Correlations 0.36-0.41 (vs. accelerometry) High test-retest reliability ($r=0.98$, $p<0.01$)

Table 1.9 (continued) Summary of existing computerised and internet-based physical activity assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
The Multimedia Activity Recall for Children and Adolescents (MARCA) (Ridley *et al.*, 2006)	Australia	Children	Based on CDPAQ Self-administered Activities recalled in time slices of 5 min or more Timeline slider for indication of activity duration Video examples of different activity intensities	Physical activity level (PAL) Minutes MVPA Total Minutes of physical activity	Not reported	No	Test-retest reliability: ICC 0.88 to 0.94 Method comparison: Correlation 0.35 to 0.45 (against Actigraph accelerometry) (PAL, MVPA (0.35), locomotion)
Computerised ACTIVITYGRAM (Welk *et al.*, 2004)	US	Children	Based on paper-based Previous Day Physical Activity Recall (PDPAR) Self-administered Time-grid divided into 30min intervals; primary activity in each interval selected with intensity	Activity bouts of self reported moderate to vigorous activity (minutes)	Not reported	No	No differences in mean activity bouts, and correlations 0.35-0.53 (compared with PDPAR) Correlations 0.33-0.50 (compared with accelerometry). Agreement was higher in schools where more support during administration

Table 1.9 (continued) Summary of existing computerised and internet-based physical activity assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
Physical Activity questionnaire (FPACQ) (Philippaerts *et al.*, 2006)	Belgium	Adolescents (12-18 years)	Self-administered Usual week activity Domains of activity (school activity, transportation, leisure time sports, sedentary)	Hour per week each domain, MET per hour each domain Sport intensity index (MET) Frequency hard and moderate activity	Not reported	No	Test-retest reliability 0.68-1.00 Sport participation (leisure time), sport participation (+ transport) and frequencies of moderate and hard activities significantly correlated with accelerometry

MET = metabolic equivalent, MVPA = moderate to vigorous activity

Table 1.10 Summary of existing computerised and internet-based combined dietary and physical activity assessment tools

Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
Peas@tees (McLure *et al.*, 2009)	UK	Children	Self administered Recall of a typical school day and weekend day Segmented day format Visual memory prompts Designed by computer-gaming expert Timeline slider for physical activities	Minutes MVPA Diet variables not reported	Mean = 15 minutes (SD 4.1).	Yes	Method comparison against accelerometry reported Underestimation MVPA (bias – 21 min; 95% LOA -146 to 105) Te-retest stability (n=49, aged 9-10 years) ICC = 0.75 (95% CI 0.62 to 0.84)
The Synchronised Nutrition and Activity Program (SNAP™) (Moore *et al.*, 2008)	UK	Children	Program features: 24 hour recall structured full day Segmented day format Visual memory prompts Review at end of completion Designed by computer-gaming expert Timeline slider for physical activities	Count of food/drink items (no portion size) Minutes MVPA	15-40mins	Yes	Between-method agreement ±1 count for majority food groups (vs MPR dietary interview) No fixed or proportional bias for MVPA (vs accelerometry). Mean difference -9 minutes.

Table 1.10 (continued) Summary of existing computerised and internet-based combined dietary and physical activity assessment tools

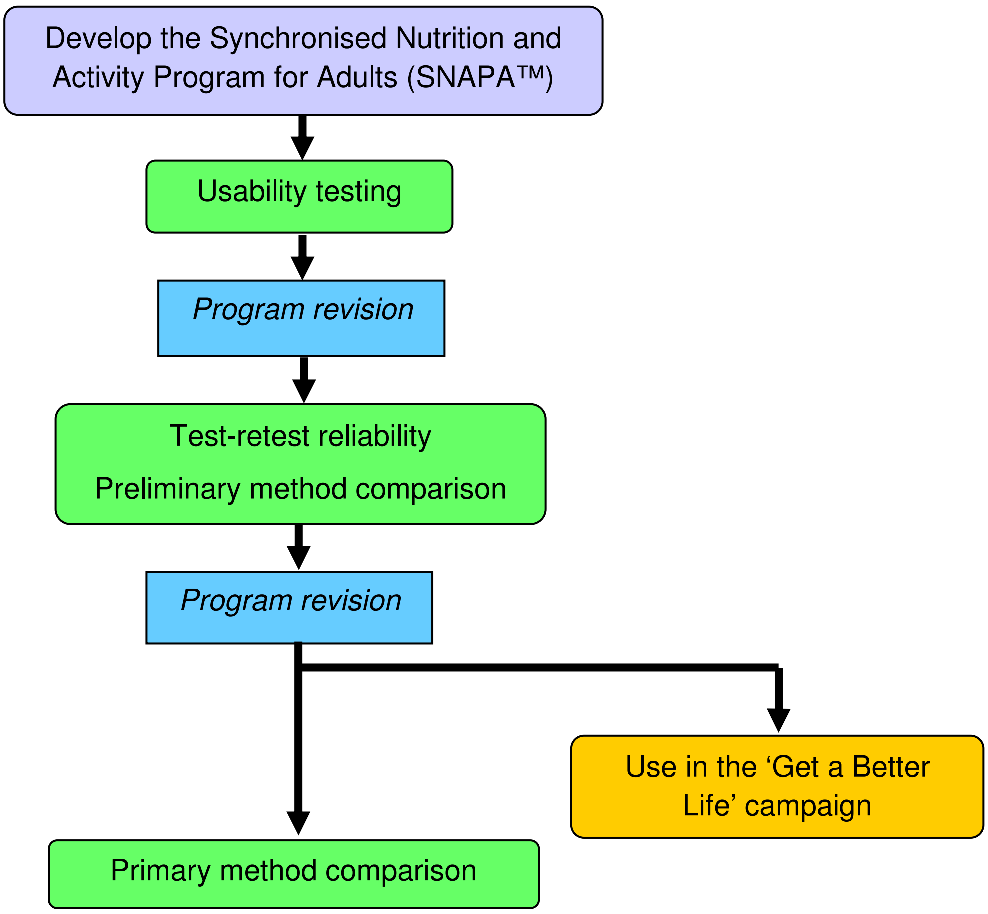
Program	Country	Population	Description	Outcome level	Completion time	Internet-based	Validation work
REALITY (Jackson *et al.*, 2009)	UK	Children	Based on a 24 hour multiple pass recall Ability to add options available	Macro-nutrient Minutes MVPA & VPA Sedentary time	Not reported	Yes	Significant correlation for energy, fat and carbohydrate intake, and approaching significance for protein (24 hour recall) No relationship with accelerometry, but trend for vigorous activity.

MVPA = moderate to vigorous activity, VPA = vigorous physical activity

1.7. Overall aim and structure of thesis

The overall aim of this thesis is to describe the development and evaluation of a novel internet-based assessment tool designed for the simultaneous assessment of dietary and physical activity behaviours in adult populations called the Synchronised Nutrition and Activity Program for Adults (SNAPA™). The evaluation work consisted of three separate studies: a usability testing study, a test-retest and primary method comparison study, and a more in-depth primary method comparison study. Between the two method comparison studies, the program was used in a population health promotion campaign, 'Get a Better Life', to assess diet and physical activities of the participants. The program of work is displayed in figure 1.14.

Figure 1.14 Flowchart of programme of work



The following chapters will describe the development of SNAPA™ (chapter two) and report on the usability testing (chapter three); the test-retest and preliminary method comparison study (chapter four); the use of SNAPA™ in the Get a Better Life campaign (chapter five); and the primary method comparison study (chapter six). Finally, I will discuss the overall findings of this programme of work, and suggest future directions (chapter seven).

Chapter Two: Development of the Synchronised Nutrition and Activity Program for Adults

2.1. Introduction

As described in section 1.4 a number of computer programs have been developed to collect data on either diet or physical activity behaviours; however, to my knowledge, no programs designed for use in adult populations currently exist that collect data on these behaviours simultaneously.

This PhD work expands on previous Durham University and Teesside University projects (peas@tees and SNAP^{TM}) that successfully developed and evaluated a prototype online assessment tool and an updated version (McLure *et al.*, 2009; Moore *et al.*, 2008), which records dietary intake and physical activity behaviours in children. This current work aimed to develop and evaluate a similar prototype for use in an adult population to be named the Synchronised Nutrition and Activity Program for Adults (SNAPA^{TM}).

The "**P**atterns of **E**ating and **A**ctivity in **S**chool children **at Tees**side" (peas@tees) program was developed by two PhD students, Sally McLure and Mark Taylor, at Teesside University between 2004 and 2007, with the help of the computer programmer Sean Crooks. The program was designed for use in school children and was evaluated in children aged 9 to 10 years (McLure *et al.*, 2009). Children completing peas@tees are asked to report activities carried out and foods and drinks consumed on a typical week day and a typical weekend day. In 2007, the **S**ynchronised **N**utrition and **A**ctivity **P**rogram (SNAP™) was developed by Moore and colleagues (including McLure) at Teesside University, again with the help of Sean Crooks, in an effort to overcome limitations identified in peas@tees. SNAP™ was a new program and was developed using lessons learnt from the peas@tees evaluation work. For reasons discussed later in this chapter, the biggest difference between peas@tees and SNAP™ is that SNAP™ asks children to report activities carried out and foods and drinks consumed on the previous day. SNAP™ has been evaluated in children aged 7 to 15 years (Moore *et al.*, 2008; Moore *et al.*, unpublished) and is currently being used to collect diet and phyiscal activity data in a three-year intervention project funded by the World Cancer Research Fund, called TeesCAKE.

The development of the Synchronised Nutrition and Activity Program for Adults, was prompted by the need for an internet-based diet and physical activity assessment tool for the Community Challenge Project (full details of which are reported in chapter five), in addition to my interest in the measurement of obesity-related behaviours (diet in particular) and the natural progression to develop an adult tool to complement the child SNAP™ tool at Teesside University. SNAPA™ was also a new program, but again, its development was informed by findings and lessons learnt from the previous evaluation studies (of peas@tees and SNAP™). SNAPA™ does share some features with peas@tees and SNAP™, but a number of differences were incorporated into the design of the program because of the different target population.

In this chapter, the theoretical underpinning and structure of SNAPA™ is described. The program was primarily designed by me; however, advice was sought from my supervisory team and a number of colleagues with backgrounds in nutrition, physical activity, psychology, sociology, and public health, including those with previous experience of developing similar programs for use with children. All computer programming aspects of this work were completed by two computer programmers employed by Teesside University, Mr Sean Crooks and Mr David Cumbor. I arranged consultations with the programmers before the work began to explain my ideas and I developed the questions, process flowcharts and notes that they used to inform the program development, and transform the plans to reality. During the development of SNAPA™, I met with the programmers at various time points to discuss and view progress and make any revisions required. The development of SNAPA™ took place from December 2006 to July 2007, with further revisions following each evaluation phase.

The principle behind this work was not to develop an entirely new method of measuring diet and physical activity, but to enhance existing methods, that have a known reliability and accuracy, with technology to develop a novel measurement tool.

2.2. Aims and objectives

Aim:

- To develop a novel, low burden, engaging, accurate and reliable web-based program for the simultaneous assessment of diet and physical activity behaviours in adults at a group/public health level

Objectives:

- To work with computer programmers to develop an internet-based computer program which collects data on previous day physical activity and diet behaviours
- To identify and incorporate internet-based computer program characteristics that are appropriate for use in a adult population
- To identify and incorporate processes that allow efficient data entry and processing
- To identify and incorporate strategies to enhance recall in an online environment
- To ensure data collected by the internet-based computer program allows the estimation of variables that can be related to public health targets

2.3. Principles of the Synchronised Nutrition and Activity Program for Adults (SNAPA^{TM})

The Synchronised Nutrition and Activity Program for Adults (SNAPA^{TM}) is a computerised previous day recall method, accessed via the internet, which asks users to report both dietary and physical activity behaviours. Although there are many limitations involved in recall methods, in reality these methods are heavily relied on and, it seems reasonable to speculate, will be for many years. Expensive and highly specialised methods (biomarkers, duplicate diets, physical activity monitors) are beyond the capabilities, resources and budgets of many research projects, and even more so for evaluations of public health initiatives and programmes trying to meet standard evaluation frameworks (Roberts *et al.*, 2009).

An advantage of using a recall method is that minimal attention bias is associated (lessened if user is unaware that they will be recalling their behaviours). The main biases that are involved in recall methods are those associated with the cognitive processes that are involved in recall. Understanding these processes enables strategies to be employed in the development of SNAPA™ (or any questionnaire) to improve accuracy (Jobe and Mingay, 1989).

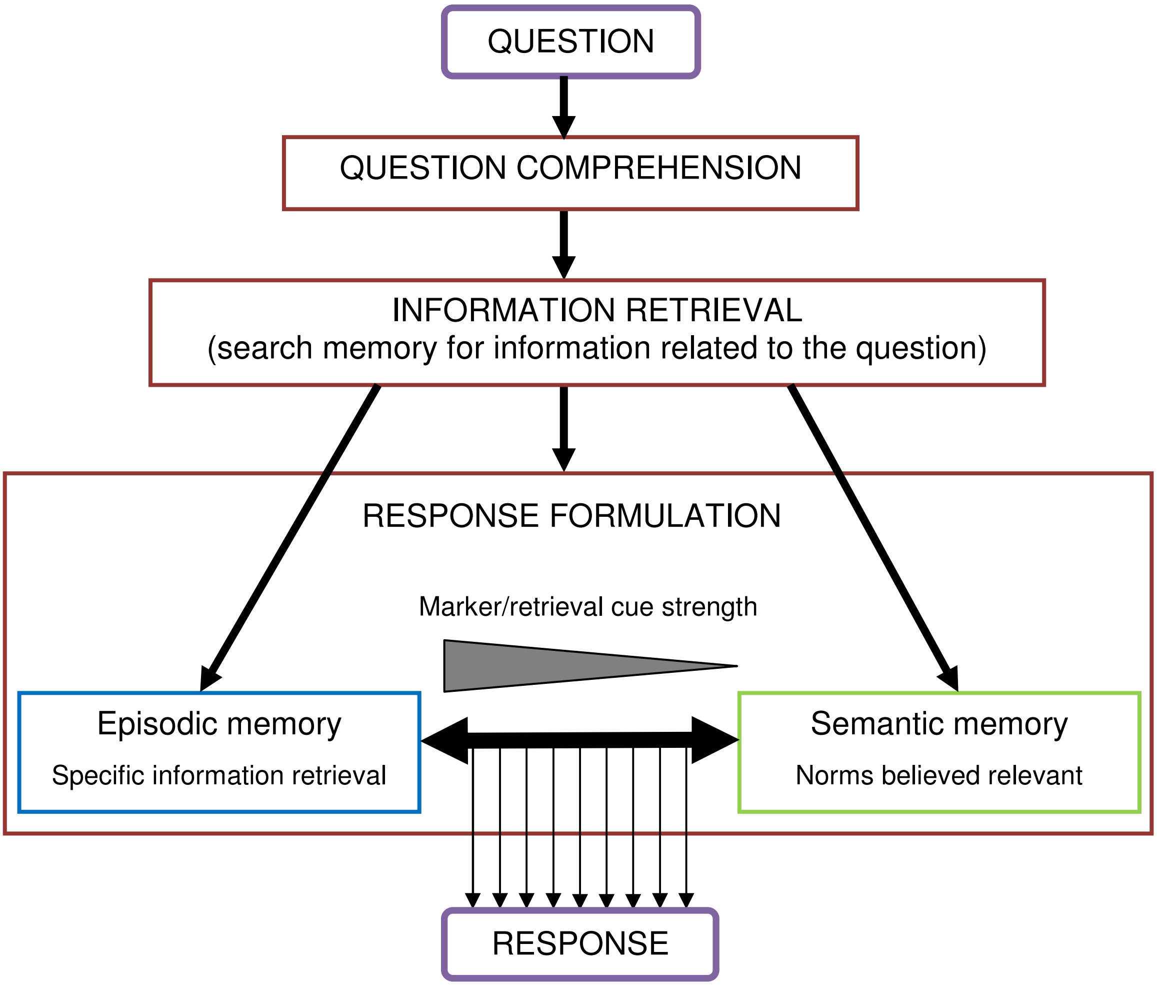
2.3.1. Overview of cognitive processes involved in recall and strategies used in the Synchronised Nutrition and Activity Program for Adults

The process of answering questions asked in any survey, questionnaire or instrument involves the following stages: question comprehension, information retrieval and response formulation (figure 2.1). The response formulation stage consists of all of the mental processing that takes place when forming a response (Smith, 1991). When recalling previous events autobiographical memory is used. Autobiographical memory is the memory system where memories that have arisen from events during an individual's life are stored (Williams *et al.*, 2008). Autographical memory consists of episodic memory (memories arisen from specific events, objects or people at a specific time and/or place) and semantic memory (general knowledge and facts) (Tulving, 1972). Therefore, responses generated through autographical memory, are a mixture of specific information retrieved from an actual event or stimuli, and norms believed to be relevant to the question based on underlying knowledge.

Simultaneous recall of dietary and physical activity behaviour

In the field of energy balance and obesity research, both diet and physical activity are behaviours of interest. Currently these behaviours are often measured using separate questionnaires or instruments which incur separate completion, processing and analysing stages. Combining the measurement of both behaviours in one instrument may be a more streamlined approach, reducing burden for both subjects and researchers, and cost. In addition, recalling both behaviours simultaneously may have added cognitive benefits, resulting in more accurate recall of both behaviours. Diet and physical activity events are inexplicably interconnected by temporal and causal links; accessing

Figure 2.1 Cognitive processes involved in behaviour recall



information about one can enable information to be accessed about the other (Bradburn *et al.*, 1987). Diet and physical activity events generate effective memory markers (or retrieval cues) for each other. For example an individual may recall: "I went for a walk before having my lunch", "After my evening meal, I watched T.V" and "I ate a snack when working on the computer". These memory markers strengthen the ability to retrieve specific information from episodic memory (Smith, 1991) (figure 2.1), therefore the higher and/or stronger the number of retrieval cues, the higher the likelihood of an event being recalled. Other markers or retrieval cues may include location (where the event took place) and time (when the event took place) and have also been incorporated into the development of SNAPA™ (see later in this chapter).

The use of memories of events to trigger memories of other events, in essence, works by adding context to the events. The concept is known as context reinstatement and is based on the principles of encoding specificity and feature overlap proposed by Tulving and colleagues (Tulving and Thompson, 1973; Tulving, 1983). Context reinstatement is an effective technique that is used in cognitive interviews with crime witnesses (Esgate and Groome, 2005). Mandler also provides useful analogies of this process using every day examples of recognising a line from a poem through the retrieval of preceding and following lines; and recognising a football player by identifying his team and his position in that team (Mandler, 1980).

Although the theory suggests that recalling diet and physical activity behaviours simultaneously should result in more accurate recalls, to my knowledge, no published studies exist that have investigated this principle. Although in its infancy, interest is growing around the targeting of multiple behaviours rather than single behaviour in public health (Prochaska *et al.*, 2008). Changing both diet and physical behaviour is advised for health promotion and the prevention and treatment (National Institute for Health and Clinical Excellence, 2006; World Health Organisation, 2004) and most obesity prevention interventions target both behaviours. Therefore, it is surprising that the cognitive effects of the simultaneous measurement of these behaviours have not been explored previously.

It may also be interesting to investigate whether the simultaneous recall of diet and physical activity is more effective at capturing one of the behaviours more than the other, i.e. recalling diet stimulates a more accurate recall of physical activity, and/or vice versa.

Recall time period

SNAPA™ was designed to recall a one day period. Although a number of self report questionnaires/methods collect data beyond one day, the longer the time period asked to recall, the greater the reliance on memory and thus the potential for error. Asking for recall of recent events, i.e. previous day, will decrease potential error as the greater the amount of time between an event and its recall, the less distinctive the event, and therefore more reliance on semantic memory (Linton, 1982). A study carried out by Smith and colleagues (Smith *et al.*, 1991) found that match rates for dietary recalls declined as the length of time between the eating occasion and recall increased. When recalling dietary intake for a week, subjects' recalls were best for the last day of the week (the day before the recall) and worst for the first day of the week, with match rates declining by approximately 3% per day (Smith *et al.*, 1991). Similar findings were reported in children's recall of physical activity, where physical activity of previous day could be recalled reasonably accurately but the children had difficulty with days further back in a 7-day recall (Wallace *et al.*, 1985).

Actual day verses typical day

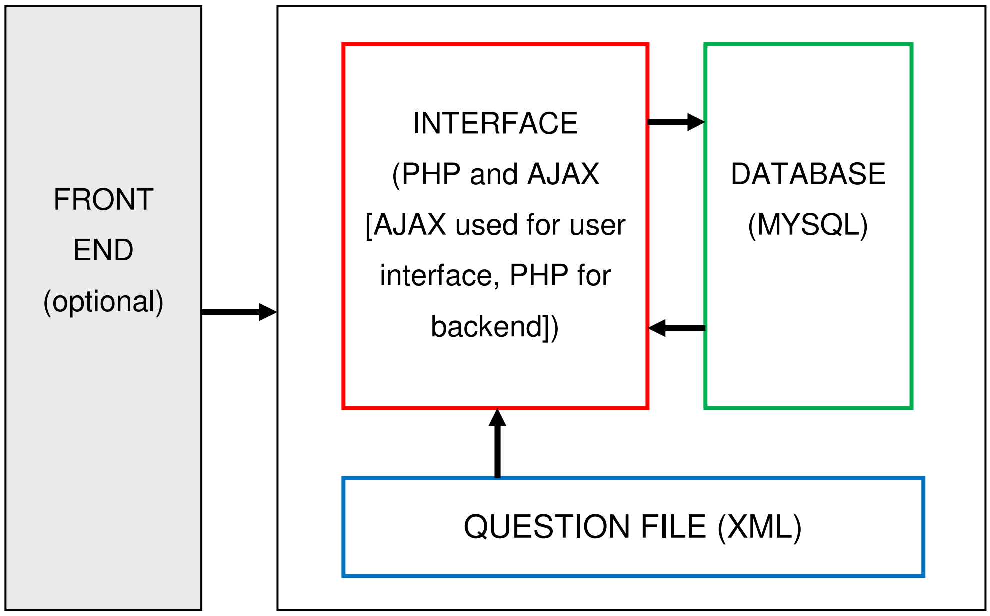
Asking participants to recall actual events forces cognitive distinction of specific episodes and reduces intrusion on episodic memory by semantic memory (Durante and Ainsworth, 1996) (figure 2.1). Semantic memory is more likely to come into play when recalling 'typical' behaviours, allowing for 'intrusion' memories (memories of events that the individual believes occurred, but in reality did not) (Bower *et al.*, 1979).

From examples of physical activity self-report questionnaires, those that ask participants to recall 'typical' or 'habitual' levels, generally show lower validity coefficients than those with shorter and specific (actual) recalls (Sallis and Saelens, 2000).

2.4 Technological overview

SNAPA™ was written using PHP, MySQL and AJAX (incorporating JavaScript and XML technologies) to allow secure data transfer and storage. All the site's graphics and styles were contained within a CSS file and one html file for easy re-design. Questions are loaded from an XML file (which can be separately accessed for editing). A PHP file is run to compile the question XML into a series of XML-PHP pages for AJAX to use. AJAX posts to a PHP file with the answers, and the PHP arranges the data, performs calculations and stores these within the database (MySQL). SNAPA™ can be linked to an external front end (for example a study website) where additional questions (for example screening questions, consent process) can be asked prior to access to the program. This is optional depending on the needs of the study. An example of this is given in chapter five where SNAPA™ was used to collect data in the 'Get a Better Life' campaign.

Figure 2.2 Technological overview of SNAPA™



2.5 Site graphics and styles

The aesthetic design of SNAPA™ has changed over the duration of this work. The changes have mainly involved different colour scheme and logos, depending on the project the program was being used for. The program was originally developed for use in a population-wide health promotion campaign that was to be used in a Food Standards Agency funded study called the Community Challenge Project. The population-wide health promotion campaign was initially given the name 'Teesside on the Move'. The 'Teesside on the Move' logo and colour scheme were incorporated into the version of SNAPA™ that was used in the usability testing (chapter three) and preliminary method comparison and test-retest study (chapter four) (figure 2.3; please note that this figure is for the demonstration of the appearance of SNAPA™ and larger figures will be presented later in this chapter where text is more visible), which were part of the pilot work carried out for the Community Challenge Project. During the development of the population-wide health promotion campaign, that ran parallel to the Community Challenge Project pilot work, the campaign was renamed ‘Get a Better Life’, after the involvement of the local media group, Gazette Media Group, and their marketing team. SNAPA™ was therefore re-designed to incorporate the ‘Get a Better Life’ identity (figure 2.3) and this version was used for the duration of the campaign (chapter five).

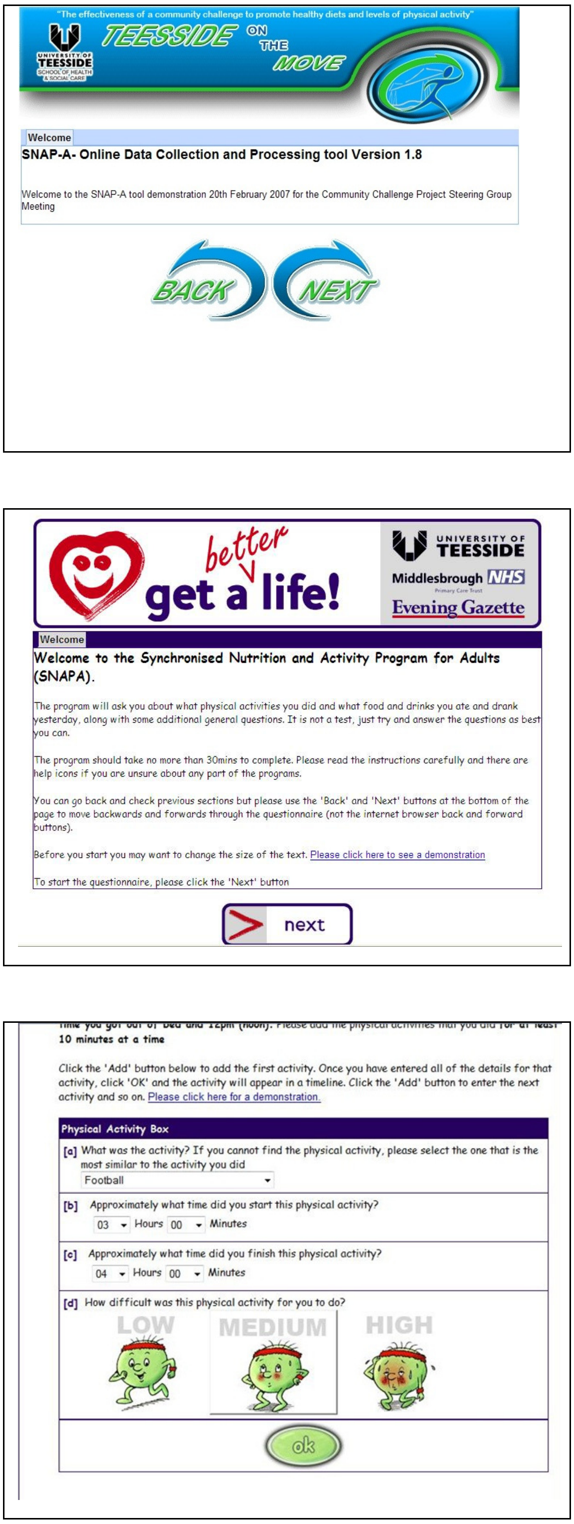
Finally, for the primary method comparison study (chapter six) the association with the ‘Get a Better Life’ campaign was deemed unnecessary and potentially confusing, therefore the aesthetic design was changed to incorporate the study name the ‘Patterns of Eating and Activity Study (PEAS) III’ (figure 2.2), which was a continuation of a series of studies carried out by Teesside University and Durham University: peas@tees (McLure *et al.*, 2009) and PEAS II (Moore *et al.*, unpublished). It is therefore desirable to develop future versions of the program with a consistent yet neutral (no project identity) design so that it can be used in any project without the cost (financial and time) of redesigning each time.

Figure 2.3 Site graphics and styles of SNAPA™ for a) Teesside on the Move, b) Get a Better Life, and c) Patterns of Eating and Activity Study (PEAS) III

a)

b)

c)



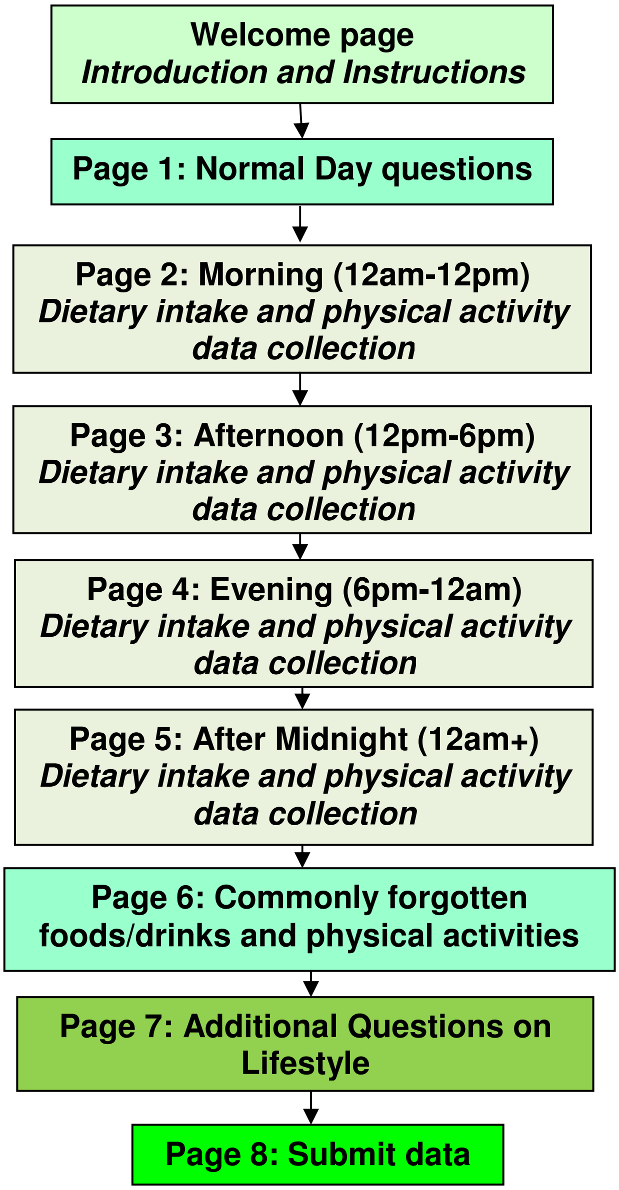
2.6 Trade marking

To help enhance recognition of the program and its purpose to the wider public (i.e. academics, researchers in the field) and distinguish the program from other potential tools of its kind, the name ‘SNAPA’ carries the unregistered trade mark symbol (™). Although an unregistered trade mark does not have any legal status, it can be used to inform others that a term, slogan, logo or other indicator is being claimed as a trade mark (International Trademark Association, 2010). Unregistered trade marks may have some legal protection through the common law action of passing off; however it can often be hard to prove the requirements and therefore registering a trade mark is the only way of ensuring intellectual property protection (Intellectual Property Office, 2010). If funding can be secured for future development and use of the program, registering the name “SNAPA” as a trade mark will be explored.

2.7 Questionnaire structure

SNAPA™ consists of a number of sections over multiple web pages (figure 2.4). The main difference between SNAPA™ and the previous prototypes, peas@tees and SNAP™, is that the program is not structured around set activities associated with a structured day, i.e. those carried out during a school day (travel to school, morning break, etc). As the program was designed for use in general adult populations, it would have been inappropriate to design the program around a 9 to 5 working day, as this would exclude a significant proportion of the population, for example those who are part-time workers; shift workers; unemployed; students; retired; carers; and homemakers.

Figure 2.4 Overall structure of SNAPA™

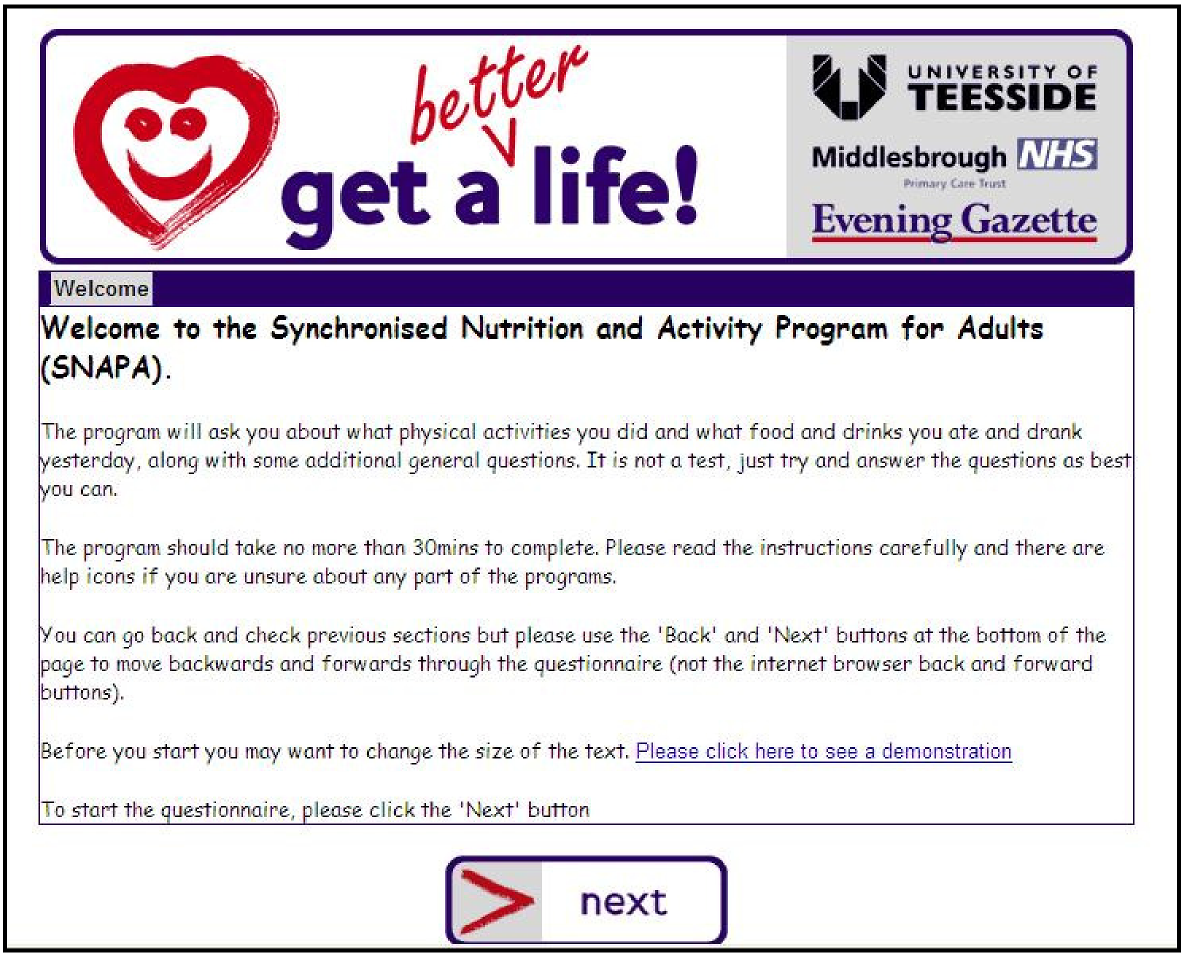


The activities associated with a structured school day provide convenient anchor points which segment the day. These anchor points may also create the encoding associations that are used in the retrieval process as described earlier. Segmenting strategies have shown to increase recall of physical activity in children (Baranowski, 1988). Although this approach does not appear to have been investigated in adults, it was believed the theoretical cognitive benefits were such to warrant its incorporation in SNAPA™. The program is divided into four time periods: Morning (12am (or time woke up) to 12pm (noon)); Afternoon (12pm to 6pm); Evening (6pm to 12am); and after Midnight (if required) during the collection of diet and physical activity data. Asking users to report meals before physical activities provide additional anchor points, which may improve the recall of physical activity.

The program was also not structured around specific meal times, i.e. breakfast, lunch, dinner etc, as meal classification can differ depending on where an individual lives (or has lived), for example in the North East region of England the meal usually taken at midday is often referred to as ‘dinner’ rather than ‘lunch’, where as ‘dinner’ would be used to classify an evening meal in other parts of the country.

2.7.1. Welcome page

Figure 2.5 Screen shot of the SNAPA™ welcome page



The welcome page introduces the user to SNAPA™ (and the project that the tool is being used for if appropriate) along with some general instructions for using the program (figure 2.5). The page also includes a demonstration for changing the text size if this is required (added after findings from the usability testing; chapter three).

2.7.2. Normal day questions

The program begins by asking the user whether yesterday was a normal or typical day, in general and in terms of food and drink consumed, and activities carried out (figures 2.6 and 2.7). These questions were based on those used in the 24 hour dietary recall interview used in the Low Income Nutrition and Diet Survey (Nelson *et al.*, 2007). The purpose of these questions is to attempt to gain some insight into the context of the data being collected, which may be especially important if only one day of data is being collected.

During the development of SNAPA™ there was discussion around the use of the normal day questions as a screening for completion. By situating these questions before recall is begun, the opportunity is available to ask users to complete the program on a day that is representative of their typical diet and physical activity behaviours if they do not feel that the current previous day was typical. This may lead to data that gives a more accurate estimation of habitual dietary and physical activity behaviours. However, it was also considered that it would cause overriding frustration and additional burden to the user if time and opportunity for completing the program is limited, possibly resulting in the program not being completed at all. In this current work these questions were used as a potential aid for data interpretation. However, in this situation the questions may be more advantageously situated after the diet and physical activity recalls, enabling users to reflect on the behaviours recalled and making a clearer judgement as to whether they represent a typical day. Conversely, an advantage of asking the typical day questions before the main recall is that they may act as a recall enhancing strategy. The questions instigate the user to reflect on the events that occurred during the previous day, to which their separate diet and physical activity occasions are associated.

Figure 2.6 Flowchart of the SNAPA™ normal day questions

Would you say that yesterday was an average day?

- Yes it was a normal day
- It was a special occasion (e.g. a party)
- I was feeling unwell
- I was in training or taking part in a sports event
- I was feeling stressed more than I am usually
- I was feeling bored more than I am usually
- I was feeling upset or unhappy more than I am usually
- I was feeling tired more than I am usually
- I was on holiday

↓

Please have a think about what you had to eat yesterday - from when you woke up to when you went to sleep.

Do you think that what you had to eat yesterday (type and amount of food) is what you would eat in an average day?

- Yes
- It was more than I usually eat
- It was less than I usually eat

↓

Please have a think about what you had to drink (non-alcoholic and alcoholic) yesterday - from when you woke up to when you went to sleep.

Do you think that what you had to drink yesterday is what you would drink in an average day?

- Yes
- It was more than I usually drink
- It was less than I usually drink

↓

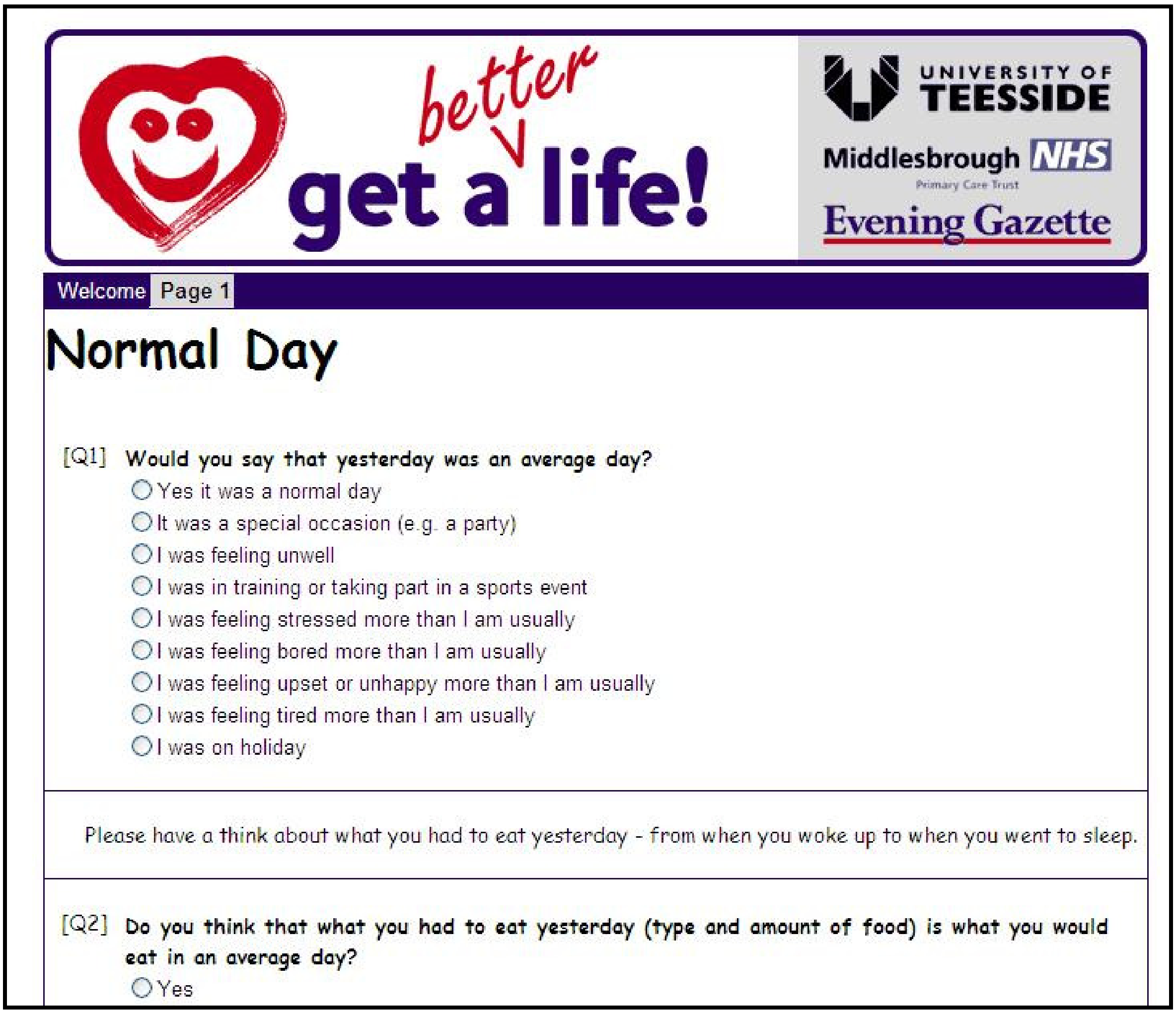
Please have a think about what types of physical activities you did yesterday - from when you woke up to when you went to sleep.

Do you think that the amount of time, difficulty and types of physical activities you did yesterday are what you would do in an average day?

- Yes
- It was more than I normally do
- It was less than I normally do

An argument against using these questions as a screening method is that a 'typical day' is very subjective and sometimes difficult to define. Is any day a normal day?

Figure 2.7 Screen shot of the SNAPA™ normal day questions



2.7.3. Dietary intake questions

In 'Morning', 'Afternoon' and 'Evening' sections of SNAPA™ users are first asked to recall the foods and drinks consumed the previous day during the time period (figures 2.8 and 2.9). The design of SNAPA™ encourages users to report food items by eating occasion (or meal). Using meal-based cues, rather than food-based is thought to be a more effective strategy for recall (Smith, 1991). Users are asked to select the time the food(s)/drink(s) were consumed, how they would describe the eating occasion (breakfast, lunch, dinner, tea or snack between meals) and where (location) the food(s)/drink(s) were consumed. Users are then asked to select the first food or drink consumed from a predefined list of food or drink items, followed by the type of food/drink (for example diet, regular, low fat) if applicable and a portion size estimation (options provided are food/drink specific). Users were asked to estimate the portion size of the food or drink consumed using standard household measures (specific to the food item being reported).

Finally, if applicable, users are asked if the food was cooked in fat. In initial plans of SNAPA™, this final question asked users ‘how the food item was cooked’. The purpose of this question was always to determine if any foods were cooked in fat (i.e. fried or roasted in oil, butter, margarine or animal fat), thereby affecting its fat content. This question is only asked for foods where this may be the case (for example, it is unlikely that chocolate would be deep fried, although this may happen on occasion!), therefore the cooking method would not always be asked for. By asking users specifically to only report on cooking methods involving fat, users need not report on cooking methods that would not affect fat content (e.g. vegetables that are boiled vs. cooked in the microwave), thus reducing burden and avoiding confusion.

Once the options are selected, users are instructed to submit the food/drink item by selecting ‘OK’. Users are instructed to repeat the process for all the foods and drinks consumed during that time period. The initial three selections relating to the eating occasion: time, description and location, do not reset automatically once a food/drink item is submitted. This allows users to enter a number of food/drink items consumed within the same eating occasion without the need to re-select these details for each food/drink item.

Figure 2.8 Flowchart of the SNAPA™ diet intake section questions

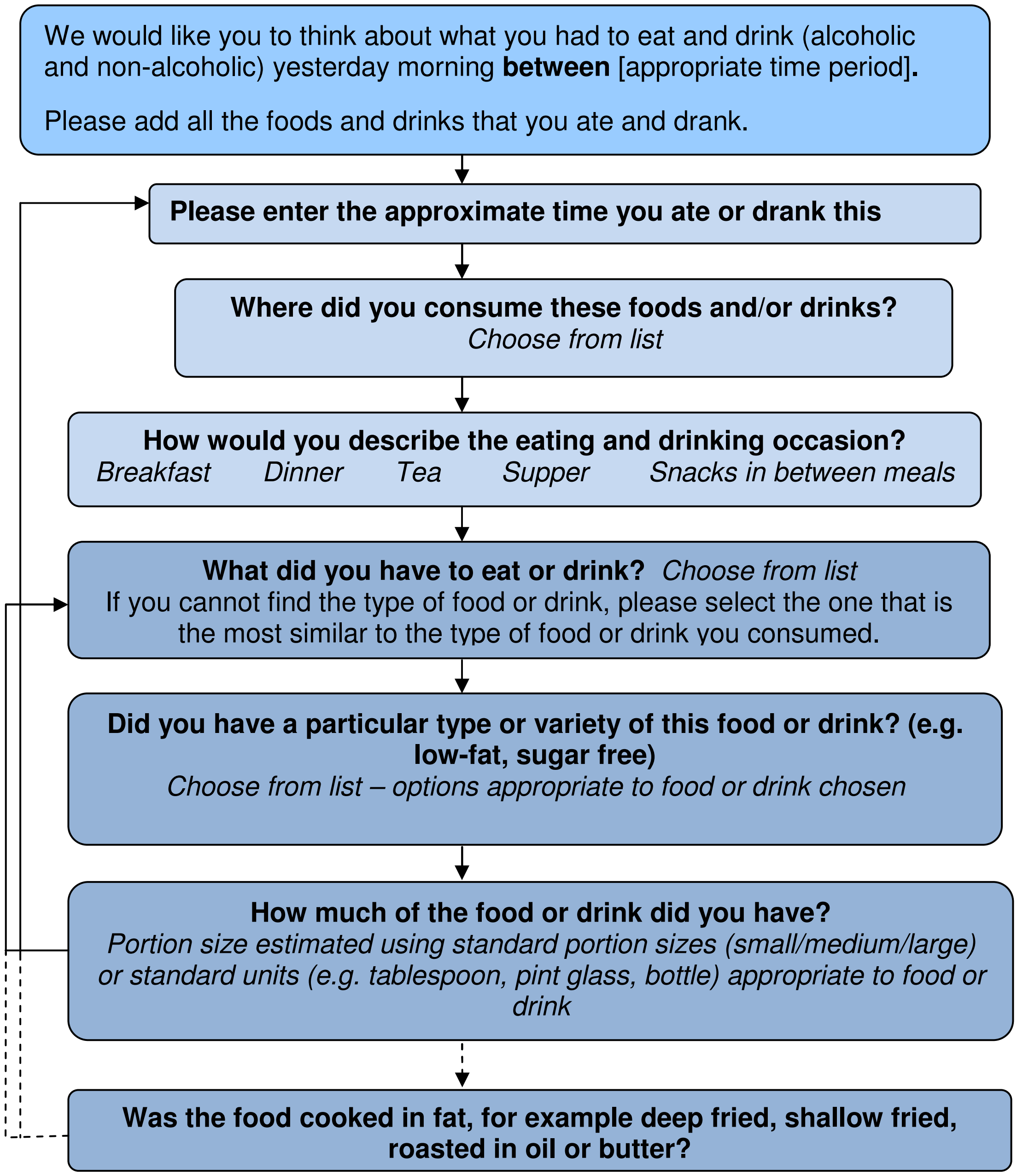
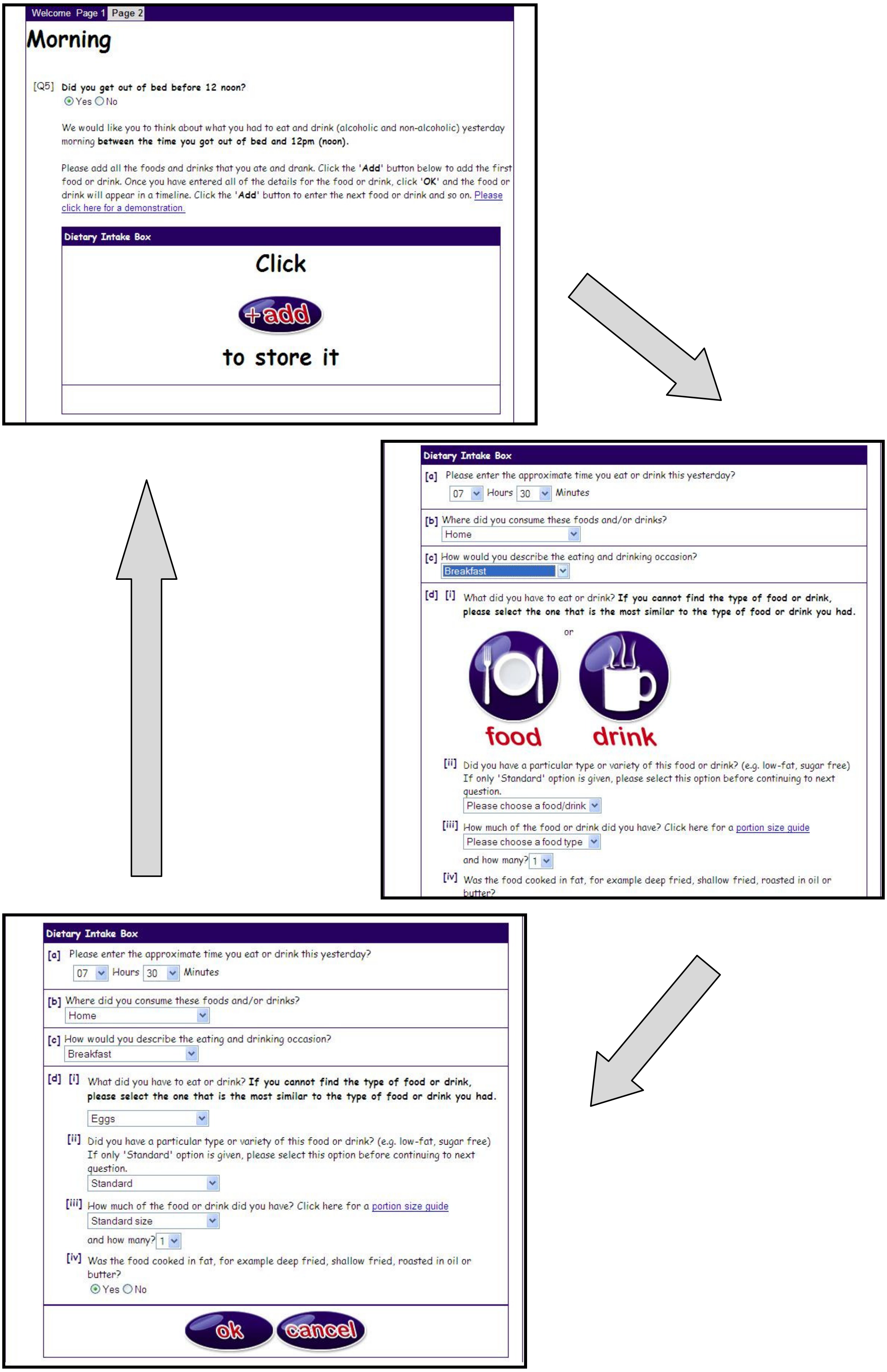


Figure 2.9 Screen shots of the SNAPA™ diet question process



2.7.4. Physical activity questions

Once the diet intake questions are completed in each section SNAPA™ asks the user to list the physical activities that they carried out the previous day during the specified time period (figures 2.10 & 2.11). Users are asked to select the activity from a predefined list, the time they began the activity, the time they finished the activity and how difficult they found the activity by selecting one of 3 options: 'Low', 'Moderate' or 'Hard'. Once these options were selected, users were instructed to submit the data by clicking 'OK', and then repeat the selections for the next activity carried out. The process is then repeated until all the activities carried out during the specified time period are submitted.

Users were asked to enter activities that were carried out for at least 10 minutes. This instruction was designed to reduce participant burden, so that time was not spent reporting activities for every minute of the day. Also, UK government recommendations for physical activity are for moderate activity carried out in bouts of 10 minutes or more (Department of Health, 2004), therefore physical activity reported in this time period was believed appropriate.

Figure 2.10 Flowchart of the SNAPA™ physical activity section questions

We would like you to think about the types of physical activities you did yesterday from [appropriate time period]. These can be activities done in or around the home (e.g. housework, gardening or watching TV), sport or leisure activities (e.g. football), transport related (e.g. walking or driving) or in employment (e.g. standing and walking). Please add all the physical activities that you did for **at least 10 minutes** at a time.

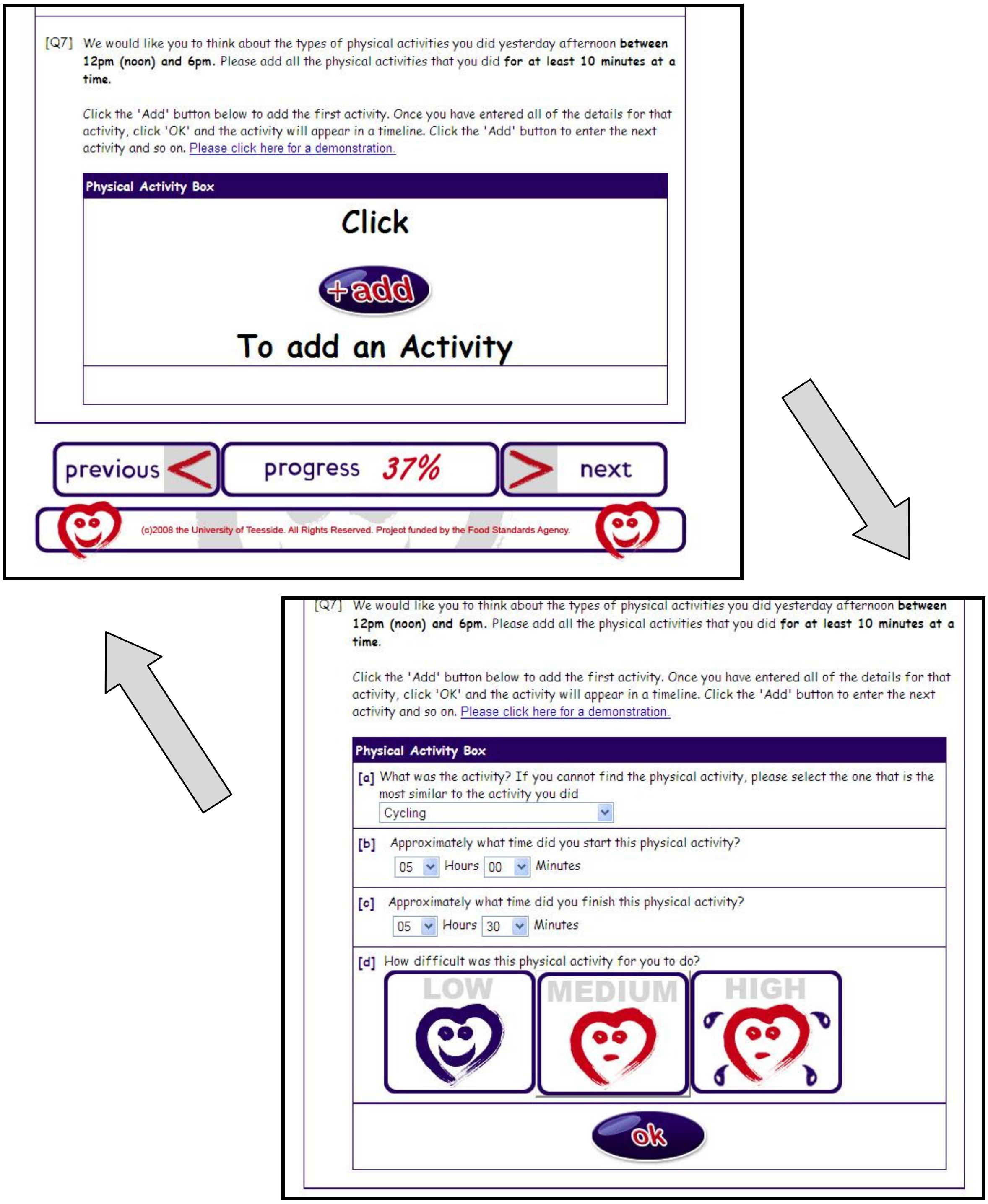
What was the activity? *Choose from list*
If you cannot find the physical activity, please select the one that is the most similar to the activity you did

Approximately what time did you start this physical activity?

Approximately what time did you finish this physical activity?

How difficult was this physical activity was for you to do?
Easy, Moderate, Hard (graphics to illustrate)

Figure 2.11 Screen shots of the SNAPA™ physical activity question process



2.7.5. Forgotten Foods/drinks and activities

Once the user has completed the morning, afternoon and evening sections, reporting all food and drinks consumed, and activities carried out, they are instructed to proceed to the next page where a list of commonly forgotten foods, drinks and activities are provided (figure 2.12). The list of commonly forgotten foods, drinks and activities was developed using results from focus groups carried out in adults in Middlesbrough (Teesside University, data unpublished) for another study being carried out by researchers at Teesside University. Users are instructed to navigate back to the previous page and add any activities prompted by the list that were not previously recalled.

Figure 2.12 Screen shot of the SNAPA™ forgotten food/drinks and activities page

2.7.6. Additional Lifestyle questions

The final section of SNAPA™ asks users additional lifestyle questions such as their current weight, how often they take part in structured activity, smoking status and alcohol consumption. These data are collected for the potential use in secondary analysis and correcting for other behaviours such as smoking and alcohol behaviours. The current version of SNAPA™ does not contain questions related to age, gender, height or demographic data. SNAPA™ was originally designed to be used for the measurement of dietary and physical activity behaviour in studies, where these additional data were collected through other methods. However, it may be a useful if SNAPA™ had the optional capacity to collect additional data such as demographics.

Depending on the requirement of the study, multiple completions of the program may be required over a number of consecutive days or days within a small time period. A further improvement of the program may be to put a mechanism in place so that the additional lifestyle questions are only asked during the first completion of the program at each measurement period, as the answers are unlikely to change over a short period of time, reducing additional burden to the user.

2.7.7. Additional features

Progress bar

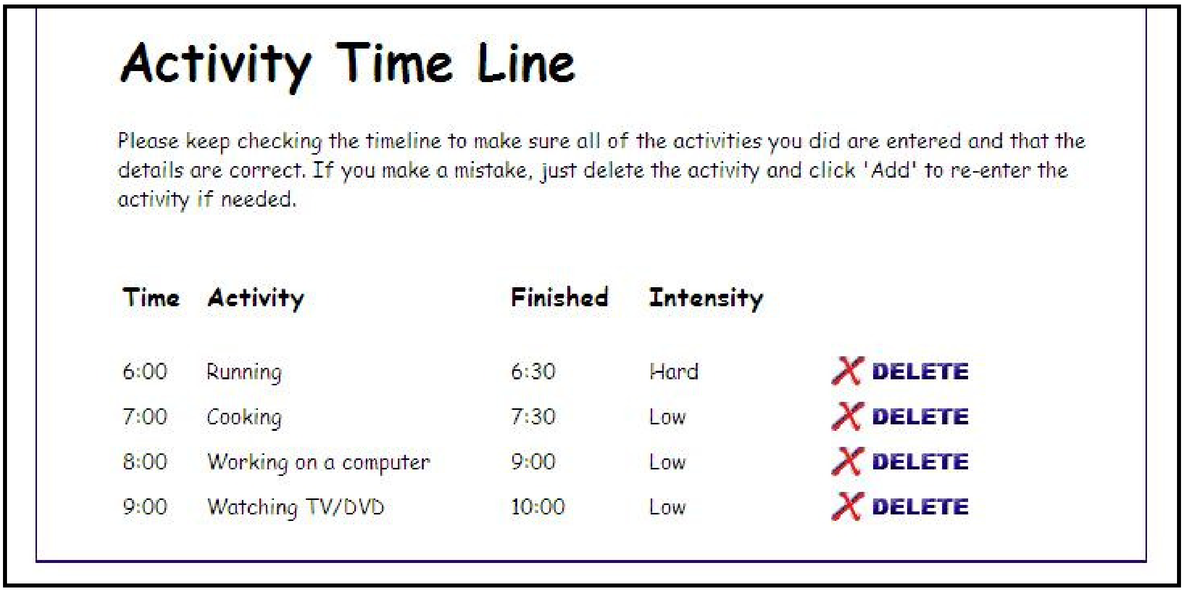
On each page of SNAPA™ a progress bar is displayed indicating the percentage of the program that has been completed, therefore indicating to the participant how much is to complete (figure 2.13).

Figure 2.13 Screen shot of the SNAPA™ progress bar

Timelines

During the completion of the diet and physical activity questions, each time a food/drink or activity is submitted the details of the food/drink or activity are loaded on to a timeline which is visible beneath the question section of the webpage (figure 2.14). The timeline is designed to facilitate recall by providing a visual summary of the foods/drinks and activities carried out the previous day, including time (and location in the case of foods/drinks), which the user can review to ensure the data entered is correct and identify any gaps in the recall.

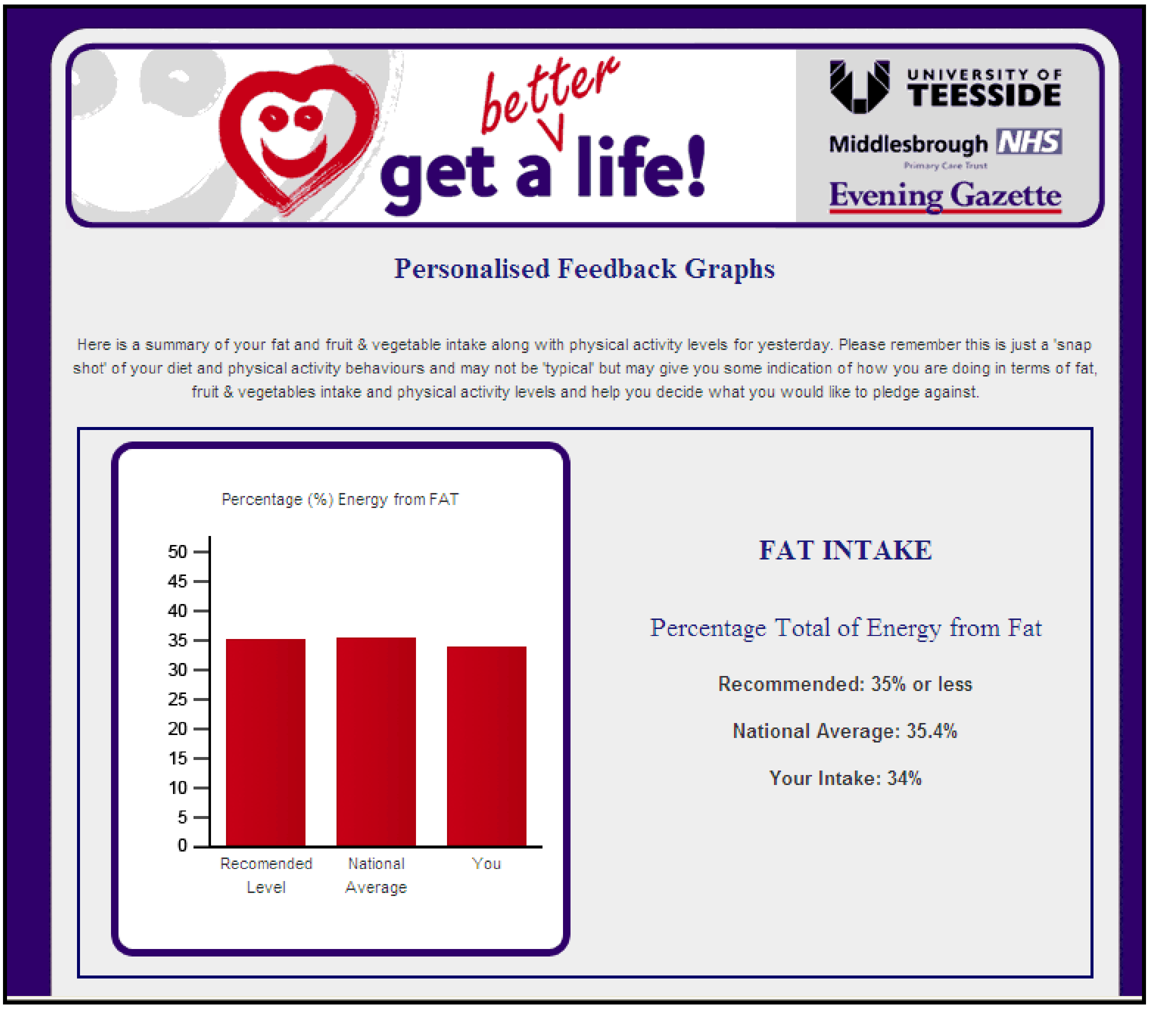
Figure 2.14 Screen shot of the SNAPA™ diet and physical activity timelines



Feedback

Once all of the sections of SNAPA™ are completed, users are instructed to submit their data. These data can then be used to generate personalised feedback for the participant. Providing feedback gives users an incentive to complete SNAPA™, aiming to increase motivation and decrease user perception of burden (Kohlmeier *et al.*, 1997). The personalised feedback provides a visual indication of users' current behaviours in relation to government recommendations for dietary fat intake, fruit and vegetable intake, and physical activity levels. However, as SNAPA™ is not designed to assess dietary and physical activity levels at an individual level (especially with only one day of recall), it is clearly stated that the feedback represents a 'snap shot' of the individual's behaviour (figure 2.15).

Figure 2.15 Screen shot of the SNAPA™ personalised feedback



2.7.8. Completion time

SNAPA™ was designed to take approximately (and ideally less than) 30 minutes to complete. Experience with other types of assessment methods (mainly food frequency questionnaires) has shown that many people are unwilling to invest time in filling out lengthy forms/questionnaires that take one hour or more to complete (Kohlmeier, 1995).

2.8 Food item and physical activity option lists

SNAPA™ contains 102 main food and 18 drink options. The addition of food item specific sub-groups (e.g. reduced-fat, 'diet', sugar-free) results in a total of 248 food item combinations (appendix A). There are 78 physical activity options (appendix B).

The diet item option lists were developed using a combination of findings from the National Diet and Nutrition Survey (Henderson *et al.*, 2002) and the results from the focus groups carried out in Middlesbrough (Teesside University, data unpublished) as previously mentioned. The list was compiled by me and then checked by colleagues with nutrition or dietetics training. To ensure that nationally representative food and drink items were included on the list, it was checked that foods and drinks reported by at least 25% of respondents from the National Diet and Nutrition Survey were included in the diet item lists (Table 2.1), although the list did include some items that were reported by less than 25% of respondents. There was no scientific justification to using a cut-point of 25% or more respondents; however, it was believed to be sufficient to ensure that the most popular foods and drinks consumed by British adults were included in the SNAPA™ options. Twenty-five out of a total of 120 food or drink options reported in the National Diet and Nutrition Survey (Henderson *et al.*, 2002) were not included in the SNAPA™ food item list.

The purpose of asking users to report the 'type' (sub-group) of certain foods is to identify any food items that may vary significantly in terms of fat and/or energy content. Therefore, food sub-groups were mainly 'diet' or 'reduced fat' vs. 'regular' versions of a food item. This additional question also allowed food combinations to be added (for example, jam added to toast) as discussed below. Subgroups such as 'decaffeinated' coffee, 'herbal' teas or flavours of crisps were not included as these would not significantly affect fat and/or energy intake and would add unnecessary burden. A sub-group option that was included however was 'wholemeal' or 'wholegrain', a dietary component that is also strongly linked to health (Jacobs *et al.*, 1999; Liu *et al.*, 1999; Steffen *et al.*, 2003b; Wang *et al.*, 2007). The ability of SNAPA™ to collect data on wholegrain foods accurately is not explored in this current work, but this may be of interest in the future evaluation work and may be considered in future development work.

Table 2.1 Foods consumed by 25% or more respondents in the National Diet and Nutrition Survey for adults aged 19 to 64 (from Henderson et al., 2002)

Type of food	% consumers
Savoury sauces, pickles, gravies and condiments	92
White bread	91
Other potatoes & potato dishes	84
Other vegetables	80
Chicken & turkey dishes	79
Other raw and salad vegetables	78
Tea, as consumed	77
Other cheese	76
Semi-skimmed milk	73
Bacon & ham	71
Potato chips	71
Coffee, as consumed	71
Raw tomatoes	69
Biscuits	66
Tap water	66
Eggs	63
Beef, veal and dishes	62
Buns, cakes & pastries	60
Carrots - not raw	56
Savoury snacks	56
Chocolate confectionary	56
Peas	55
Table sugar	54
Pasta	53
Leafy green vegetables	53
Rice	52
Other bread	52
Bananas	52
Apples & pears	51
Whole grain & high fibre b'fast cereals	48
Carbonated soft drinks - not low calorie	47
Sausages	45
Fruit juice	45
Oily fish	44
Baked beans	44
Other fruit	44
Beer & lager	44
Other fried/roast potatoes & products	42
Butter	41
Wine	41
Meat pies and pastries	39
Preserves	37
Wholemeal bread	36
Other b'fast cereals	36
Whole milk	36

Table 2.1 (continued) Foods consumed by 25% or more respondents in the National Diet and Nutrition Survey for adults aged 19 to 64 (from Henderson et al., 2002)

Type of food	% consumers
Yogurt	36
Other reduced fat spread	35
Coated and/or fried white fish	35
Soup	34
Other cereals	33
Carbonated soft drinks - low calorie	31
Pork & dishes	30
Vegetable dishes	30
Citrus fruits	28
Pizza	27
Ice cream	27
Soft margarine, not polyunsaturated	27
Other meat and meat products	26
Burgers and kebabs	25
Bottled water	25

In an attempt to reduce burden on the user and time when completing the program, a number of composite food (for example, lasagne, chilli con carne, pasties, pies) and food combination (for example, toast and jam, fish and chips) options were provided. Common composite foods and food combinations were also identified from findings from the focus group work in Middlesbrough (Teesside University, data unpublished).

The activity option list was also developed using results from the focus groups incorporated with the sports, games and physical activities listed in the Sport and Leisure General Household Survey (Fox and Rickards, 2004).

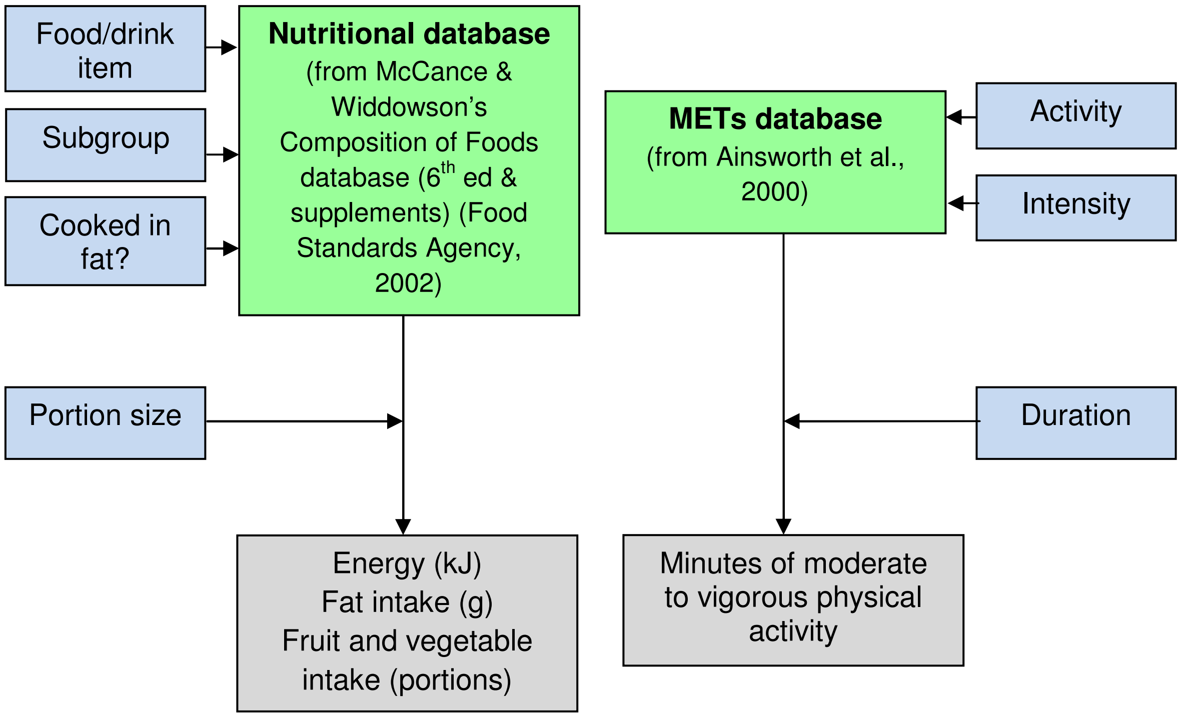
2.9 Underlying databases, data processing and analysis

Figure 2.16 shows an overview of the underlying databases used in SNAPA™ and how the different components of the recall are used to estimate the outcome variables.

2.9.1. Nutrient database

Each combination of food/drink item, type of food/drink and cooked in fat/not cooked in fat option was assigned a food code from the Composition of Foods Database (Food Standards Agency, 2002) and corresponding nutrient composition per 100g. Where possible, data for composite foods that were available in the Composition of Foods Database were used. Nutritional data for the food

Figure 2.16 Overview of the databases and outcome variables used in SNAPA™



combination options were calculated using nutritional data from the Composition of Foods Database for the individual food items, along with the standard portion sizes. Table 2.2 shows an example calculation for a meat sandwich, made with white sliced bread.

Nutrition composition data for food/drink items not included in the Composition of Foods Database were obtained from manufacturer details. Nutritional data for a dish local to Middlesbrough, the chicken 'parmo', was not available in the Composition of Foods Database. A chicken parmo comprises of a chicken breast deep fried in breadcrumbs and covered in béchamel sauce and cheese and is usually served with chips. A recipe based on 'Teesside' recipes found after an internet search ("BBC - Tees Parmo!", 2003; "Ever had a loverly parmo", 2003) was analysed in the dietary analysis software WISP version 3.0 (Tinuviel Software, Anglesey, UK), resulting in 740g portion consisting of 4966 kJ and 74g fat. This is likely to be an underestimation of energy and fat content, as after the development

Table 2.2 Example calculation of nutritional values for a composite food item

				Nutrient values*†		
M&W Database code	**Food item description**	**Portion size description**	**Portion size (g)**	**Energy (kJ/portion)**	**Fat (g/portion)**	**Vegetable (portion)**
11-468	White bread	2x medium slice‡	72	670.3	1.2	0.0
17-021	Margarine, soft, poly-unsaturated	2x medium spread‡	14	429.4	11.6	0.0
18-474	Beef, rump steak, lean only, grilled	Medium slice‡	37	275.7	2.2	0.0
New values for combination food			**123**	**1375.4**	**15.0**	**0.0**

*calculated using [nutrient per 100g] x [portion size/100]

† alcohol (g/portion) and fruit (portion) also calculated

‡from Food Portion Sizes (Ministry of Agriculture Fisheries and Food, 1993)

of SNAPA™, a report carried out by the North Yorkshire County Council Trading Standards Service, that analysed two chicken parmo meals (including chips) from two different take away establishments, found the average meal weighed 1032g, with 20571 kJ and 147g fat (Hudson, 2007). Assuming 165g as an average portion of chips (Wrieden and Barton, 2006), resulted in values of 8924 kJ and 127g fat for the parmo alone, almost double that calculated using the recipe.

The portion size options provided to the users were derived from the Ministry of Agriculture, Fisheries and Food Standard Food Portion Sizes (Ministry of Agriculture Fisheries and Food, 1993). Portion sizes are food item specific and were based on standard household measures or simply ‘small’, ‘medium’ and ‘large’ descriptions. For example, if a user selects ‘lasagne’, they can select either a ‘small’, ‘medium’ or ‘large’ portion; if a user selects ‘sugar’ they can select either a level teaspoon or heaped teaspoon; and if the user selects ‘beer’ they can select ½ pint, pint, bottle or can.

Fruit and vegetable portions were defined using the portion size guidelines from the NHS 5 a Day program and the Food Standards Agency (approximately 80g of fresh fruit or vegetables, and 40g of dried fruit) (www.5aday.nhs.uk; www.eatwell.gov.uk). When the ‘fruit’ and ‘vegetable’ food items were selected, users were asked to estimate how many portions were consumed using the NHS and Food Standards Agency guidelines. Composite foods and recipes containing fruit and/or vegetables were assigned fruit and/or vegetable portion values based on recipe data from the Composition of Foods Database (Food Standards Agency, 2002). The assignment of fruit and vegetable values to composite foods was extremely important as these types of foods contribute substantially to overall fruit and vegetable intake (O'Brien *et al.*, 2003).

Calculation of diet variables

The weights of the food/drink items consumed were assigned using two methods: firstly using the estimated portion size selected by the user, which was linked to standard food portion size data (Ministry of Agriculture Fisheries and Food, 1993), or, secondly simply using the average portion size for that food or drink from tables developed by Wreiden and Barton (Wrieden and Barton, 2006). The usefulness of asking users to estimate portion sizes was explored in the preliminary method comparison study (chapter four). One of the primary outcome variables for dietary behaviour, calculated using the nutrient composition data, was the percentage of food energy provided by fat. Percentage of food energy from fat was calculated using the following formula, assuming that 1g alcohol provides 29kJ energy and 1g fat provides 37kJ energy:

$$\text{Percentage food energy from fat} = \left(\frac{\text{Fat intake (g)} \times 37}{\text{Total energy intake (kJ)} - [\text{Alcohol intake (g)} \times 29]} \times 100 \right)$$

The second primary outcome variable for dietary behaviour was the total number of portions of fruit and vegetables. As described above, each food item/sub-group combination was assigned a fruit and/or vegetable portion value, therefore the sum of fruit and vegetable values from each food item reported provides the intake value for the day. All reports of baked beans and other pulses, and fruit juice in one day were classed as one portion.

2.9.2. Physical activity database

Each combination of reported activity and intensity was assigned a metabolic equivalent (MET) value drawn from the Compendium of Physical Activities (Ainsworth *et al.*, 2000). One MET is the estimated resting energy expenditure with activities defined in multiples of resting metabolism. Activities with a MET value of three and above and six and above were classed as moderate and vigorous intensity activities, respectively. The primary outcome variable for physical activity behaviour was the total minutes of moderate-vigorous physical activity (the sum of all reported activities of three METS and above; figure 2.17).

Figure 2.17 Example calculation of total minutes of moderate to vigorous activity (MVPA)

If Intensity >=3 then Duration is shown, If Intensity <3 then value 0 is shown

Activity	Intensity (METS)	Duration (mins)	Minutes of mod/vig activity (mins of METS>=3)
Walking	3.8	15	15
Riding in car/bus	1	30	0
Walking	3.8	10	10
Sitting - talking, reading, writing, typing	1.8	240	0

Total minutes of MVPA = 25

MET = metabolic equivalent

2.10 Exporting and processing data

The data collected by SNAPA™ are stored in a MySQL database in four tables: “SVDATA_ACTIVI”, containing the activity code, start time, end time and intensity of each activity reported; “SVDATA_FOOD”, containing the meal, time, location, food ID, subgroup, estimated portion size, and cooked in fat answer for each food item reported; “SVDATA_otherq”, containing answers to each questions in the additional lifestyle questions section; and “SVDATA_userrecords”, containing the ID number of each user, the unix time[2] of each data submission; and the conversion of unix time into a readable date, hours and seconds format. All activity, food item and question answer data stored are linked to the user’s ID number and the unix time stamp of when the data were submitted.

The MySQL database is accessed via the host site password protected phpMyAdmin function. To process the data and calculate the outcome variables each data table is exported as EXE files that are then imported into a Microsoft Access database, which contains tables of the underlying nutrient and MET values data. The “food id” table contained a description of each food item and its assigned ID number; “food info” table contained information on food subgroup, portion size and corresponding nutritional values (per portion) for each food ID; “activity info” contained each activity option and corresponding MET value per intensity option (low, moderate, high) specific to the activity.

The tables are manipulated using SQL (Standard Query Language) queries to obtain the desired outcome variables. Before the SQL queries are run, each table is linked using the relationships database tool (appendix C).

Physical activity data processing

The first step of the physical activity data processing for the calculation of minutes of moderate to vigorous activity is to retrieve each activity reported by each user and the corresponding start time, end time and MET value (appendix D: SQL Query 1). The data retrieved is then exported into an existing Microsoft Excel

[2] Unix time is the number of seconds elapsed since midnight Coordinated Universal Time (UTC) of January 1, 1970.

template (appendix E) to calculate the duration of each activity, and check the data for any anomalies. Once the data has been processed in the Excel template, it is imported as a new table on the Access database named “Processed activity data”. A SQL query is run to calculate the total minutes of moderate to vigorous physical activity reported each day (appendix D: SQL Query 2). If data have been collected over a number of days, a SQL query is run to calculate the mean minutes of moderate to vigorous physical activity per day (appendix D: SQL Query 3).

Dietary data processing

Data on each food reported and its corresponding nutritional values per portion (energy intake [kJ and kcal], alcohol (g), fat (g), portions of fruit and portions of vegetable), along with other variables of interest (e.g. meal name, time of eating, location), are extracted (appendix D: SQL Query 4). Further SQL queries are run to extract the total daily value of each variable per user (appendix D: SQL Query 5) and the mean daily values if data has been collected for more than one day (appendix D: SQL Query 6). These data are exported into an existing Microsoft Excel template (appendix E) to calculate percentage of food energy from fat and fruit and vegetable portions (appendix D) using the calculations described above. Counts of baked beans, other pulses, and fruit juice are identified using a series of SQL queries (appendix D: SQL Queries 7-12), and used to correct fruit and vegetable portion calculation in the Excel template (appendix E).

2.11 Summary

The Synchronised Nutrition and Activity Program for Adults (SNAPA™) was designed to address the need for a flexible, interactive and enjoyable method of assessing energy balance related behaviours in free-living adult populations, across a range of age groups and abilities. The theoretical underpinning incorporates strategies to enhance recall and allow efficient data collection and data analysis, in a standardised manner.

Chapter Three: Usability testing

3.1 Introduction

Usability problems associated with a websites and internet-based programs can cause frustration, reduce performance, waste time and can ultimately lead to non-completion. Usability testing is used to test ‘real’ usability problems that are experienced by users rather than ‘potential’ problems that may be perceived by experts (U.S. Department of Health and Human Services, 2006), and is a widely employed method for evaluating products and systems (not just websites) in terms of user performance and satisfaction. Usability testing aims to explore the usability of a website by collecting data on user’s success, speed of performance and satisfaction (U.S. Department of Health and Human Services, 2006).

The usability testing of the Synchronised Nutrition and Activity Program for Adults (SNAPA™) was carried in June 2007 so that any revisions could be made before the preliminary method comparison study was carried.

3.2 Aims and Objectives

The aim of this study was to:

- Identify any major usability issues that are associated with the completion of the novel internet-based computer program (SNAPA™)

The objectives of this study were to:

- Collect data on screen navigation during completions of SNAPA™
- Collect data on users experience of completing SNAPA™ through audio recordings

3.3 Methods

3.3.1. Ethical approval

This study was approved by the Teesside University, School of Health and Social Care Research Ethics Committee (appendix F).

3.3.2. Participants and sampling

Volunteer sampling was used to recruit participants to the usability testing study. Posters, leaflets and information sheets (appendices G and H) were placed in a number of shops and service centres throughout Middlesbrough and the Tees Valley. Potential participants interested in taking part in the study were instructed to contact the research team via telephone or email. During this correspondence, the opportunity to ask any questions was given, and if the individual was still interested in taking part, a convenient time for the participant to attend a study session was arranged.

A sample size of five participants was the recruitment target for this study. Research suggests that most usability problems are identified using three to five participants, and that using additional participants will reveal fewer and fewer new usability problems (Lewis, 1994; Nielsen and Landauer, 1993; Virzi, 1992).

3.3.3. Camtasia Studio

In order to identify usability problems in SNAPA™, the screen capture software Camtasia Studio version 4.0 (Techsmith, Okemos, USA) was used to collect data on screen navigation during completion of the tool. In addition to the navigation data, participants' audio comments on each stage of the tool were recorded using the software's audio recording function. Audio recordings were transcribed and analysed along with the video recordings to identify usability problems.

3.3.4. Usability testing protocol

Participants were invited to attend Teesside University on a specific day and time for a one hour, one-to-one study session. The sessions took place in a quiet, private room with one researcher present. At the beginning of the session, participants were given the opportunity to ask the researcher any questions about the study before completing a consent form (appendix I).

For this study a retrospective approach was used. Participants were asked to perform the task of completing SNAPA™ using a standardised scenario with a predefined list of foods and physical activities (task 1), and then watch the video recording of the on-screen actions (as recorded by the Camtasia Studio screen capture software) and comment on what they were thinking while they were entering their data at each stage (task 2) (appendix J). Participants were encouraged to complete the tool by themselves during task 1; however they could ask the researcher for guidance if they experienced difficulties which prevented them from continuing with the task. Finally, participants were then asked to complete a feedback questionnaire (appendix K). The researcher followed a pre-written script to ensure the sessions were standardised (appendix L).

During both tasks audio recordings were also captured by the Camtasia Studio software. Although the participants were not instructed to ‘think aloud’ as they completed the program (task 1), the audio recordings made during this task allowed the identification of any audio sounds or comments (positive and negative) associated with any particular actions. Concurrent ‘think aloud’ protocols (where participants give their comments when performing each action or task) have been used in usability testing, however this approach can have a negative effect on user performance and success in task completion (van den Haak *et al.*, 2003), compared with allowing users to perform tasks uninterrupted.

Revisions made as a result of the usability testing were completed before the test-retest and method comparison studies of SNAPA™ were carried out.

3.3.5. Incentive

All participants received a £5 high street shopping voucher and any travelling expenses were reimbursed.

3.3.6. Data Analysis

The audio recordings and the participant’s on screen navigation were played back and any usability issues were documented. An action was classified as an usability issue when it deviated from the optimum working procedure for the task. Usability issues were coded using an approximate model of user action (Lee, 1998). The model separates human computer interaction into three stages: Goal formation (deciding what action to do); Action Specification (determining how to do the action); and Action Execution (doing the action). Table 3.1 shows the codes assigned to each problem type with the three stages. Data collected by the feedback questionnaires were used to supplement the data collected from the audio and video recordings.

Table 3.1 Problem coding within each stage of the approximate stages of computer action model (adapted from Lee, 1998)

Stage	Code	Problem type
Goal Formation	1.1	Uncertainty about when to use a particular function
	1.2	Difficulties in understanding what a function does
	1.3	Uncertainty about relationship or distinction between user interface elements or functions
	1.4	Difficulties in conceptualizing the system
	1.5	Difficulties in seeing and reading off the screen in the initial survey of the screen
Action Specification	2.1	Cannot find action or subject
	2.2	Difficulties with terminology
	2.3	Difficulties figuring out how to do carry out an action
	2.4	Failure to choose a more effective function
	2.5	Missed a step in procedure
	2.6	Uncertainty about system status
	2.7	Difficulties with seeing or reading off the screen
Action Execution	3.1	Difficulties in carrying out an action
	3.2	Uncertainty about system status during execution
	3.3	Confused by the result of an action

The audio recordings were also transcribed and used along with responses made on the feedback questionnaire to identify any themes arising from the participant's experience of completing the program.

3.4 Results

Five participants took part in the usability testing study. Sample characteristics are described in table 3.2. Participants had a varying degree of IT experience: all had access to computers but usage ranged from two hours per month to 37 hours per week. Internet usage ranged from 0 to 15 hours per week. The mean completion time for SNAPA was 22 minutes and 22 seconds (range = 14 minutes and 37seconds to 28 minutes and 15 seconds). A number of usability issues were identified (table 3.3).

Table 3.2 Sample characteristics of participants recruited for the usability testing study (n=5)

	Frequency (percent)	**Mean (SD)**
Age (years)		35.8 (16.0)
Gender		
Male	3 (60.0)	
Female	2 (40.0)	
Ethnicity		
White	5 (100.0)	
Occupation		
Unemployed	1 (20.0)	
Employed full time	3 (60.0)	
Homemaker	1 (20.0)	

Table 3.3 Usability problems identified by participants (n=5) when using SNAPA™

Page	**Problem description**	**Problem code**	**Number of Participants**
2	Unsure how to enter first activity	2.3	5
4	Difficulty finding ‘cheeseburger’	2.1	5
4	Unclear that ‘NA’ to be selected before portion size options are given	3.1	5
4	Frustration that some food items need to be added separately (for example, butter on toast and milk and sugar in tea)	3.1	5
2 & 4	Difficulty using 24 hour clock (entered incorrect time)	2.5	3
4	Unclear how many portion sizes to add	2.5	3
3	Unsure how to enter forgotten activities	2.3	2
2 & 4	Purpose of the ‘Timeline’ was unclear	3.3	2
2	Activity not submitted	2.5	1
4	‘Cooked in fat’ question confusing	2.2	1

Despite the usability issues, comments from the audio recordings and feedback questionnaires suggested that SNAPA™ was well-received: “*really good and useful”* (participant #3); *“it will make people think about the relationship to their health”* (participant #5); and that participants found it usable despite some commenting that they possessed relatively little experience with computers: *“if I* *can do it…anyone can!"* (participant #1). Indeed, the majority of participants expressed an interest in completing SNAPA™ using their own data: *"I would like to fill it in for myself"* (participant #3). Furthermore, all the participants stated that they would be happy to complete SNAPA™ more than once if the feedback was more accurate. Worthy of note is that completion of SNAPA™ gradually became faster as the participants accustomed themselves to the program: "*a few bits that were confusing but…they became a lot easier"* (participant #4).

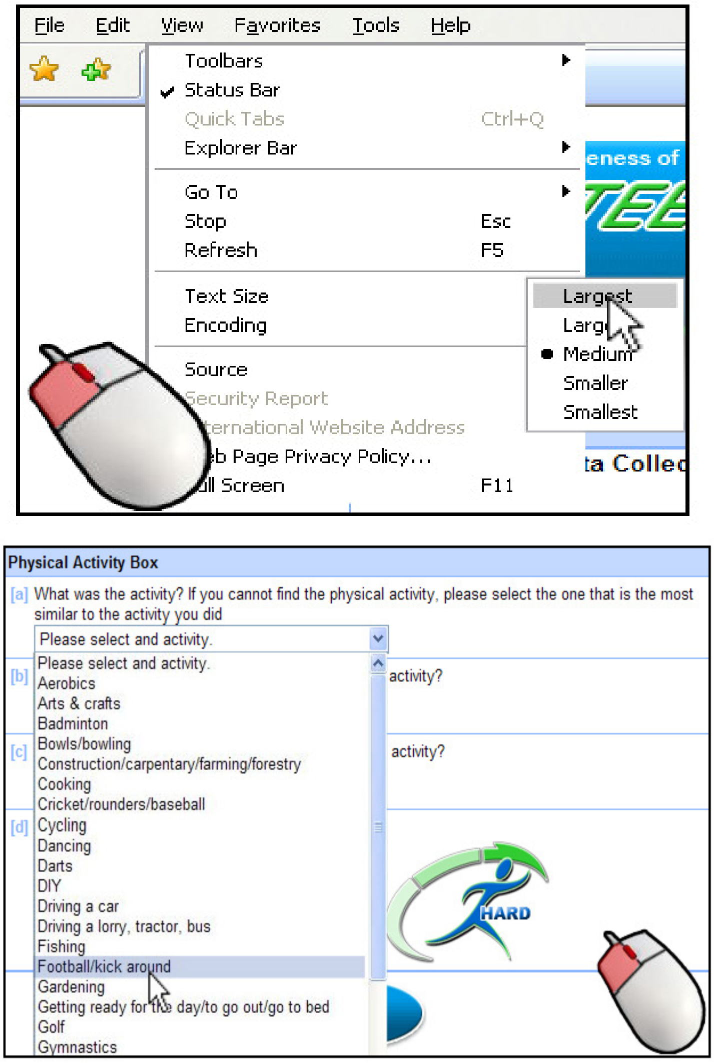
3.5 Discussion

A number of revisions were made as a result of the usability testing results before the test-retest and method comparison studies were carried out. In order to address the problem of participants being unsure of how to enter the activities and food and drinks consumed, instructions were rewritten to be more comprehensive. In addition, short flash training animations were created to "embed" inside the user interfaces for the physical activity and dietary intake entry pages to provide the user with a 'walkthrough' example on how to add and amend their entries. These animations had been kept relatively short to reduce the effect on completion time to a minimum (see figure 3.1).

Options for common food combinations (for example toast with butter, jam etc., tea with milk and sugar) were added as food intake options to make it easier for users to input multiple foods and to expedite completion times. 'Question mark' icons were also added to key areas of SNAPA™ which, when clicked, open a 'Pop-up Window' displaying helpful text to help users to complete the current element (for example in the food intake user interface, to select the 'not applicable' option for the subgroup question before a portion size can be selected). One unanticipated discovery during usability testing was that many people did not like the 24 hour format for time. This was converted into am/pm format to address this issue. Finally, new questions and data changes were added and upgraded on the site to provide more accurate source data and to correct errors, including additional improvements to some of the XML Questions.

A standardised scenario, rather than asking participants to complete their own diet intake and physical activities of the previous day, was chosen for two main reasons: primarily to ensure that participants carried out certain functions of the program that were of particular interest in the usability testing; and to gain a sense of the time taken to complete the program by participants with differing IT literacy's, which would be difficult if participants were entering different types and quantities of foods and activities. However, this does limit the study in that it does not give a clear indication of how SNAPA™ may perform in a 'real' study situation where participants enter their own data. Unfortunately, this study was affected by financial and time constraints. In an ideal world, the usability testing of SNAPA™ may have included a second set of participants completing SNAPA™ using their own data (or a larger group, divided into two, completing SNAPA™ using both

Figure 3.1 SNAPA™ Flash Training Animations



scenarios, in a counterbalanced order). Also, in the current study SNAPA™ was completed in very 'sterile' and controlled conditions. Although the current study design was useful in a number of respects, additional testing the usability of SNAPA™ in a variety of 'free-living' situations may have identified additional usability issues. However, some data on the usability of SNAPA™, although not as robust, continued to be collected throughout the following evaluation work and its use in a public health promotion study through feedback from participants (both formal and anecdotal).

An additional limitation of the current study was that, because of the financial and time constraints, only one round of usability testing was carried out. Ideally a series of repeated usability testing, or at least, before and after changes were made, would be carried out so that the usefulness of the changes can be evaluated, and any new usability problems arising as a result of the revisions can be identified (Nielsen, 2000; U.S. Department of Health and Human Services, 2006). It is also argued by others that more than five participants are need to identify usability issues (Spool & Schroeder, 2001; Woolrych & Cockton, 2001); therefore, if budget and time allows, it may be prudent to use larger sample size. This may be easier using protocols where usability testing sessions could include more than one participant. A series of one-to-one session is very time demanding. However, as argued by Nielsen (Nielsen, 2000), repeated rounds of usability testing using small samples is probably more useful than one round using a large samples.

Chapter Four: Preliminary Method Comparison and test re-test reliability

4.1. Introduction

The preliminary validation of the Synchronised Nutrition and Activity Program for Adults (SNAPA™) was carried out between July and October 2007. Concurrent validity of SNAPA™ was assessed using reference methods of physical activity and dietary assessment, over a one-day period. In the same study, repeat completions of SNAPA™ were used to evaluate short term test-retest reliability of the tool.

The main reason for the preliminary method comparison study, and subsequently why two method comparison studies are reported in this thesis (see chapter six for primary method comparison study), was to evaluate SNAPA™ before its use in the Community Challenge Project (full details of which are reported in chapter five). Consequently, this study was required to adhere to strict time constraints and, therefore, a quicker and simpler protocol was used then may be considered ideal. However, this study does provide extremely useful data for the evaluation of SNAPA™ especially in terms of whole day diet behaviours and short term reliability, and thus has been included in this thesis.

4.2. Aims and Objectives

The aims of this study were to:

- Evaluate the short term test-retest reliability of SNAPA™
- Evaluate the concurrent validity of SNAPA™ against reference methods at a group level (multiple pass recall dietary interviews and accelerometry)

The objectives of this study were to:

- Objectively measure physical activity in adults using accelerometry
- Measure dietary intake in adults using the multiple pass recall dietary interview with trained interviewers
- Measure physical activity (moderate to vigorous physical activity) and dietary intake (fat and fruit and vegetable intake) in adults using SNAPA™

- Repeat the measurement of physical activity and dietary intake in adults using SNAPA™ following a distraction task

4.3. Methods

4.3.1. Ethical approval

This study was approved by the Teesside University, School of Health and Social Care Research Ethics Committee (appendix F).

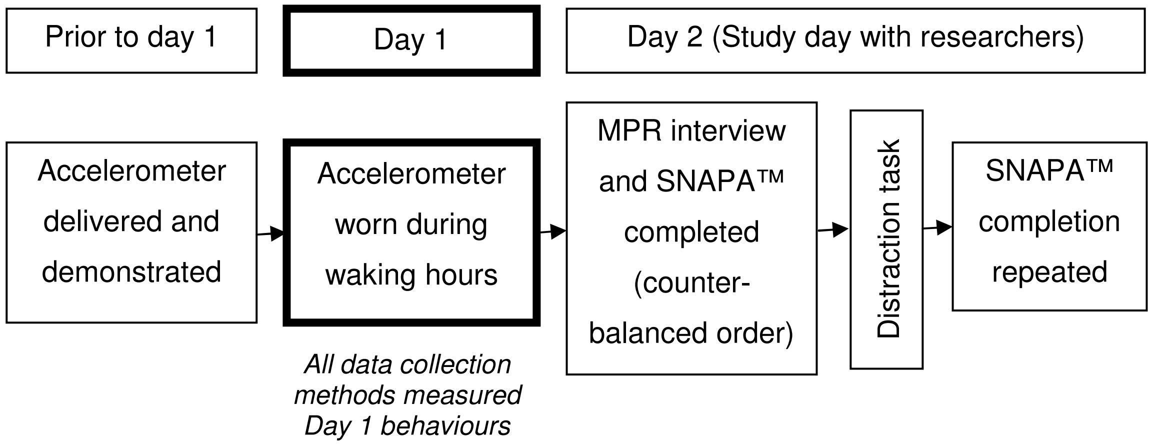
4.3.2. Participants and sampling

Volunteer sampling was used to recruit participants to the method comparison and test-retest reliability studies. Posters, leaflets and information sheets (appendices M and N) were placed in a number of shops and service centres throughout Middlesbrough and the Tees Valley, and two articles advertising the study were published in the local newspaper: The Evening Gazette (appendix O).

4.3.3. Test-retest and Method comparison protocol

A number of study days were held at a community venues throughout Middlesbrough and a number were held at Teesside University. Participants were invited to attend a study day of their choice. A member of the research team met each participant, either at the participant’s home or at a near by community venue, one or two days prior to the study day they had chosen to attend, to deliver an accelerometer (Actigraph GT1M, Fort Walton Beach, FL, USA) and gain informed consent (appendix P). The researcher gave a demonstration of how to wear the accelerometer, along with written instructions, and answered any questions from the participant. Teesside University lone worker procedures were followed by the researcher delivering the monitor. Participants were asked to wear the accelerometer during waking hours the day before their chosen study day (Day 1), removing only when bathing, showering or swimming. Participants were asked to record any periods that the accelerometer was not worn on a diary sheet provided (appendix Q). Accelerometers were handed back to the research team when the participant attended the study day.

Figure 4.1 Test re-test and preliminary method comparison study timetable



SNAPA™ = Synchronised nutrition and activity program for adults, MPR = multiple pass recall dietary interview

During the study day (Day 2), participants were asked to complete SNAPA™, in a quiet room with a researcher at hand to assist with any questions, and a 24 hour multiple pass recall dietary interview with a researcher in a counterbalanced order. A sub-sample of participants completed a distraction task (‘Who wants to be a millionaire quiz’) and SNAPA™ for a second time in order to assess short term test-retest reliability. All of the methods collected data on the foods and drinks consumed and physical activities carried out on Day 1. Anthropometric measurements were also taken during the study day.

4.3.4. SNAPA™

The development, format and completion process of SNAPA™ has been described in previous chapters of this thesis. During the study day, SNAPA™ was completed in a controlled environment in a computer laboratory (Teesside University) or computer room (community venue) where a researcher was available to answer any questions or help with any completion issues.

4.3.5. Accelerometry

The reference method of physical activity assessment for comparison against SNAPA™ physical activity data was an objective measurement of physical activity behaviour by accelerometry (Actigraph™ GT1M, Fort Walton Beach, FL, USA). The Actigraph™ GT1M is a small, lightweight motion sensor monitor that captures and stores instances of vertical movement, expressed as counts per minute. No definitive evidence exists which suggests that a particular make or model of accelerometer is more valid and reliable than another (Trost *et al.*, 2005). The Actigraph™ GT1M has been used in a number of cohort studies to assess physical activity levels of populations, including the US National Health and Nutritional Examination Survey (NHANES) (Troiano *et al.*, 2008).

Participants were instructed to wear the accelerometer on their right hip, under or over their clothes (whichever they preferred). Activity counts were analysed in epochs of one minute. The issue of epoch length has not been systematically studied in adults, however a one minute epoch is considered appropriate for studies in adults (but not children) and has typically been used in studies to develop the cut-points that correspond with moderate and vigorous physical activity (Trost *et al.*, 2005).

Accelerometry data were downloaded and saved as dat. files using the Actigraph software, Actilife (Actigraph™, Fort Walton Beach, FL, USA). The files were then processed using the MAHUffe accelerometer analysis software (Medical Research Council Epidemiology Unit, Cambridge, UK). Each minute was assigned an intensity value using the adult specific cut-points for counts per minute calculated for use in NHANES 2003-2004 (Troiano *et al.*, 2008). These cut-offs were calculated as a weighted average of criteria determined from four calibration studies (Brage *et al.*, 2003; Freedson *et al.*, 1998; Leenders *et al.*, 2001; Yngve *et al.*, 2003). A threshold criterion of 2020 counts for moderate activity was calculated as equivalent to 3 metabolic equivalents (METs). The intensity values assigned were used to estimate the total number of minutes of moderate to vigorous physical activity.

The criterion for the minimum wear time to represent a waking day was defined as 10 hours. When screening and processing the accelerometer a period of 60 minutes of consecutive zero counts was classified as non-wear time. These criteria are used as standard in accelerometry measurement (Catellier *et al.*, 2005; Craig *et al.*, 2009; Troiano *et al.*, 2008).

4.3.6. 24 hour multiple pass recall dietary interview

The reference method of dietary assessment for comparison against SNAPA™ dietary data was the 24 hour multiple pass recall dietary interview as used in the Low Income Diet and Nutrition Survey (Nelson *et al.*, 2007). The 24 hour multiple pass recall dietary interview consists of three distinct phases or 'passes': participants begin by recalling a quick list of all food and drink items consumed the previous day which is followed by a forgotten foods and drinks list read out by the interviewer designed to probe recall of any forgotten items. The interviewer then asks for a detailed description of each food and drink item (time consumed, variety, brand, portion size etc). Finally the interviewer reviews the details of the foods and drinks recalled. Participants were asked to estimate portion sizes of foods and drinks recall using either standard household measures (Ministry of Agriculture Fisheries and Food, 1993) or a photographic atlas of food portion sizes (Nelson *et al.*, 1997), whichever was appropriate to item being recalled. All multiple pass recall dietary interviews were carried out by researchers who were trained in this method and had used it previously (Moore *et al.*, 2008), and standardised interview scripts were followed (appendix R). Data were collected on standardised data collection forms.

Data collected from the 24 hour multiple pass dietary recall interviews were coded and assigned a weight value corresponding to the portion size estimation method used (Ministry of Agriculture Fisheries and Food, 1993) before being inputted into the dietary analysis software WISP (version 3.0; Tinuviel Software, Anglesey, UK). WISP provided outcome variables of total energy intake (kJ); total amount of alcohol intake (g); and total amount of fat intake (g) which were used to calculate the percentage food energy from fat. Number of portions of fruit and vegetables was calculated by dividing the total weight of the 'fruit/fruit juices' and 'vegetable' (excluding potatoes) groups provided by WISP by 80.

4.3.7. Anthropometrics

Height, weight and waist circumference measurements were taken by trained researchers. Height was measured using a free-standing stadiometer to ±0.1cm (Leicester Height Measure, Harlow Printing Ltd, Tyne and Wear, UK) and weight measured using an electronic digital scale to ±0.1kg (Tanita 800S Personal

Scales, Chasmors Ltd, London). The equipment was placed on a flat surface, and participants were asked to remove their shoes and any heavy clothing (coats, jumpers etc) for accuracy of measurements. Waist circumference was measured using a non-stretch, spring weighted anthropometric tape in the horizontal plane, midway between the inferior margin of the ribs and the superior border of the iliac crest to ±0.1cm as recommended by the World Health Organisation and the International Diabetes Federation (International Diabetes Federation, 2006; Wang *et al.*, 2003).

4.3.8. Data analysis

The short-term test-retest reliability of SNAPA™ was evaluated for each outcome variable. Systematic shift in the mean (bias) from test to retest was assessed using the mean difference and its uncertainty (90% confidence intervals, CI). The random error component was assessed using the typical (standard) error of measurement and the appropriate form of the intraclass correlation coefficient (ICC) – ICC (3,1) for reliability of a single measure and ICC (3,2) for the reliability of the mean of two measures. Uncertainty in the typical errors and ICCs was expressed using 90% CI.

The validity (correlation) coefficient (90% CI) is an appropriate statistic to examine the concurrent validity of SNAPA™. In the presence of non-uniform distributions (common for variables of this type) confidence intervals for the correlation between the SNAPA™ and the reference method were constructed for each primary outcome variable using a criterion bootstrapping resampling method (Davison and Hinkley, 2006; Efron and Tibshirani, 1993). According to Efron and Tibshirani *"The bootstrap is a computer-based method for assigning measures of accuracy to sample estimates"* (Efron and Tibshirani, 1993). The method generates a unique sampling distribution based on actual data and, therefore, produces unbiased estimates, unlike if generic distribution tables were used (Chernick, 1999; Davison and Hinkley, 2006; Efron and Tibshirani, 1993). Five-thousand resamples with replacement of size N were taken, with the validity coefficient computed on each run. A 90% CI was constructed using a simple percentile method (5^{th} and 95^{th} percentile of the 5000 correlation coefficients). The minimum number of resamples required for the construction of confidence intervals is usually considered to be 1000; however, accuracy increases as the number of resamples increases and the number of resamples in determined by the computer power and time available (Efron and Tibshirani, 1993). For this study 5000 resamples were considered appropriate. As a secondary analysis, the method described by Bland and Altman was used to explore the precision of SNAPA™ at an individual level (Bland & Altman, 1999)

During the analysis of the physical activity data collected by SNAPA™, the following activities were excluded: cycling, weight training, standing manual tasks and swimming, in order to ensure a fair comparison with the reference method. Cycling, weight training and standing manual tasks are difficult to measure using hip-worn accelerometers because little vertical movement is involved (Corder *et al.*, 2007). Participants were instructed to remove their accelerometers when showering, bathing or swimming, therefore any swimming activity would not have been recorded by the accelerometer.

4.4. Results

4.4.1. Test-retest reliability

Test-retest data was collected from 44 participants. Sample characteristics are described in Table 4.1.

The means (SD) for the repeat administrations of the SNAPA are given in Table 4.2. For moderate to vigorous physical activity there was no substantial systematic shift in the mean from test to retest. The 90% CI for the mean difference between test occasions is -15.2 to 15.7 minutes (P=0.89). The typical error (Standard Error of Measurement) is ± 36 minutes (90% CI, 31 to 46 minutes). The single measure ICC (3,1) is 0.62 (90% CI, 0.42 to 0.76) and the average measure ICC (3,2) is 0.76 (0.59 to 0.87).

Table 4.1 Sample characteristics of participants included in the test-retest reliability study study (n=44)

	Frequency (%)	Mean (SD)
Age (years)		41.4 (17.3)
BMI (kg/m^2)		27.9 (4.9)
Waist circumference (cm)		86.0 (11.4)
Gender		
Male	16 (36.4%)	
Female	28 (63.6%)	
Ethnicity		
White	42 (95.5%)	
Black African	1 (2.3%)	
Black Caribbean	1 (2.3%)	
Occupation		
Unemployed	4 (9.1%)	
Employed full time	25 (56.8%)	
Employed part time	6 (13.6%)	
Homemaker	3 (6.8%)	
Retired	5 (11.4%)	
Full time carer	1 (2.3%)	

For percentage of energy from fat there was no substantial systematic bias from test to retest. The 90% CI for the mean difference between test 1 and 2 is -1.9 to 2.2% (P=0.93). The typical error is ± 5% of energy from fat (90% CI, 4.2 to 6.3%). The ICC (3,1) is 0.72 (90% CI, 0.55 to 0.83) and the ICC (3,2) is 0.84 (0.71 to 0.91).

For portions of fruit and vegetable intake there was no substantial systematic bias from test to retest. The 90% CI for the mean test-retest difference is -1.1 to 0.30 (P=0.38). The typical error is ± 1.7 portions (90% CI 1.4 to 2.1 portions). The ICC (3,1) is 0.70 (90% CI, 0.52 to 0.82) and the ICC (3,2) is 0.82 (0.69 to 0.90).

Table 4.2 Mean (SD) for the repeat administrations of SNAPA™

	SNAPA™ 1	SNAPA™ 2
Minutes MVPA	57.6 (60.4)	56.4 (58.9)
Percentage food energy from fat	26.3 (9.4)	26.2 (9.4)
Number of FV portions	3.5 (3.1)	3.8 (3.1)

SD = standard deviation, MVPA = moderate to vigorous physical activity, FV = fruit and vegetable, SNAPA™ = Synchronised Nutrition and Activity Program for Adults

4.4.2. Method comparison

Seventy-one participants were recruited for the method comparison study. Sample characteristics are reported in table 4.3.

Table 4.3 Sample characteristics of participants included in the preliminary method comparison study (n=71)

	Frequency (%)	**Mean (SD)**
Age (years)		43.0 (16.3)
BMI (kg/m^2)		28.03 (5.2)
Waist circumference (cm)		87.01 (14.2)
Gender		
Male	25 (35.2)	
Female	46 (64.8)	
Ethnicity		
White	68 (95.8)	
Black African	1 (1.4)	
Black Caribbean	1 (1.4)	
Asian	1 (1.4)	
Occupation		
Unemployed	6 (8.5)	
Employed full time	37 (52.1)	
Employed part time	9 (12.7)	
Homemaker	8 (11.3)	
Retired	8 (11.3)	
Full time carer	2 (2.8)	
Not stated	1 (1.4)	

SD = standard deviation

Normal day responses

All participants completed the first section of SNAPA™ with questions relating to the previous day in terms of whether it was considered a normal day. Figure 4.2 and table 4.4 show the responses given by each participant for each question. More than 50% of the participants considered the previous day to be a normal day, and considered the amount of food eaten, drinks consumed and physical activities carried out to be as they would normally do.

Figure 4.2 Normal day responses from participants in the preliminary method comparison study (n=71)

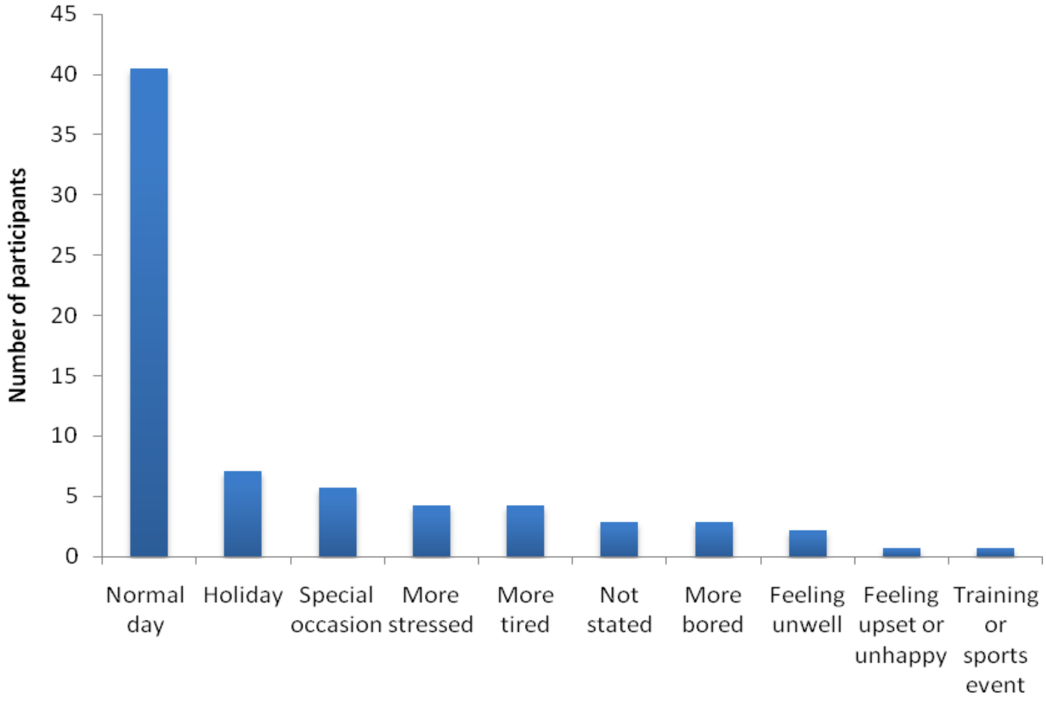


Table 4.4 The proportions of answers given by all participants (n=71) when asked if the amount of food ate, drink consumed and physical activities carried out was normal

Answer	**No of participants (%)**
Amount of food eaten yesterday?	
Normal	37 (52.1%)
Less than normal	18 (25.4%)
More than normal	13 (18.3%)
Not stated	3 (4.2%)
Amount of drinks consumed yesterday?	
Normal	40 (56.3%)
Less than normal	16 (22.6%)
More than normal	12 (16.9%)
Not stated	3 (4.2%)
Amount of physical activity carried out yesterday?	
Normal	37 (52.1%)
Less than normal	21 (29.6%)
More than normal	10 (14.1%)
Not stated	3 (4.2%)

SNAPA™ versus accelerometry

Five participants were excluded from the physical activity method comparison analysis as they did not have data collected from both methods: one participant forgot to wear the accelerometer the day prior to the study day and four participants were unable to complete the physical activity section of SNAPA™ due to technical difficulties during the study day which these participants attended.

Analysis was undertaken with and without the exclusion of a further nine participants who were identified as over-reporters (defined as participants who reported taking part in a moderate to vigorous physical activity [greater or equal to three METs], continuously for three or more hours). Table 4.5 shows the over-reported activities reported by each of the nine participants and table 4.6 shows the sample characteristics of participants identified as 'over-reporters'.

Table 4.5 Moderate to vigorous activities (≥3 METs) reported with duration of ≥3 hours by over-reporter participants (n=9), and daily total time spent in moderate to vigorous intensity activities as determined by SNAPA™ and accelerometry

Participant	Reported activity (intensity)	Duration of activity (min)	Total min MVPA from SNAPA™	Total min MVPA from accelerometer
1	DIY (hard)	195	255	11
2	Carpentry (moderate)	210	270	18
3	Golf (moderate)	210	240	161
4	Walking (moderate)	230	250	24
5	Dancing (low)	240	270	31
6	Farming (moderate)	300	300	107
7	Construction work (hard)	480	630	183
8	Walking (moderate)	945	985	9
9	Looking after children (hard)	945	1035	53

SNAPA™ = Synchronised Nutrition and Activity Program for Adults, MVPA = moderate to vigorous physical activity

All participants who wore the accelerometer exceeded the minimum required wear time of 10 hours. The average wear time of the accelerometer in the whole sample with SNAPA™ and accelerometer data was 14 hours 29 minutes. When the over-reporters were removed from the sample, the average wear time of the accelerometer was 14 hours 34 minutes.

Table 4.6 Sample characteristics of participants identified as over-reporters in the physical activity method comparison analysis (n=9)

	Frequency (%)	**Mean (SD)**
Age (years)		35.9 (14.7)
BMI (kg/m^2)		28.2 (6.5)
Gender		
Male	7 (77.8)	
Female	2 (22.2)	
Ethnicity		
White	9 (100.0)	
Occupation		
Employed full time	7 (77.8)	
Homemaker	1 (11.1)	
Retired	1 (11.1)	

SD = standard deviation

Table 4.7 shows the mean (SD) of the total minutes of moderate to vigorous physical activity determined from SNAPA™ and accelerometry for each group. The table also shows the number of participants who carried out 30 minutes or more moderate to vigorous physical activity on the day that the data were collected for.

When over-reporters were excluded from the analysis the difference between the mean minutes of moderate to vigorous physical activity from SNAPA™ and the reference method was smaller than when data for the complete sample were used. However, when reported in terms of the number of participants carrying out 30 minutes or more moderate to vigorous physical activity, agreement between the methods appeared stronger when all participants were included in the analysis. The validity (correlation) coefficient between SNAPA and accelerometry derived

Table 4.7 Physical activity outcomes determined by SNAPA™ and accelerometry

	Mins MVPA Mean (SD)		≥30mins MVPA Frequency (%)	
	SNAPA™	Accelerometry	SNAPA™	Accelerometry
All with complete data (n=66)	90.5 (164.3)	45.5 (41.9)	33 (50.0%)	36 (54.5%)
Minus over-reporters (n=57)	43.3 (64.6)	42.3 (36.3)	24 (42.1%)	31 (54.4%)

SD = standard deviation, MVPA = moderate to vigorous physical activity

moderate to vigorous physical activity when the over reporters were excluded was 0.39 (Bootstrapped 90% CI, 0.08 to 0.64). Over-reporters were removed from this analysis as it was believed that physical activity levels reported by these participants were unfeasible. In a real life study, data are usually screened for unrealistic data and removed from analysis; therefore, removing over-reporters in this study allowed the exploration of the performance of SNAPA™ as it would be used in a real life study situation.

Figure 4.3 Bland-Altman plot of the mean difference between accelerometry and SNAPA™ determined minutes of moderate to vigorous physical activity (MVPA) versus the mean of the two measurements for all participants with complete data (n=66)

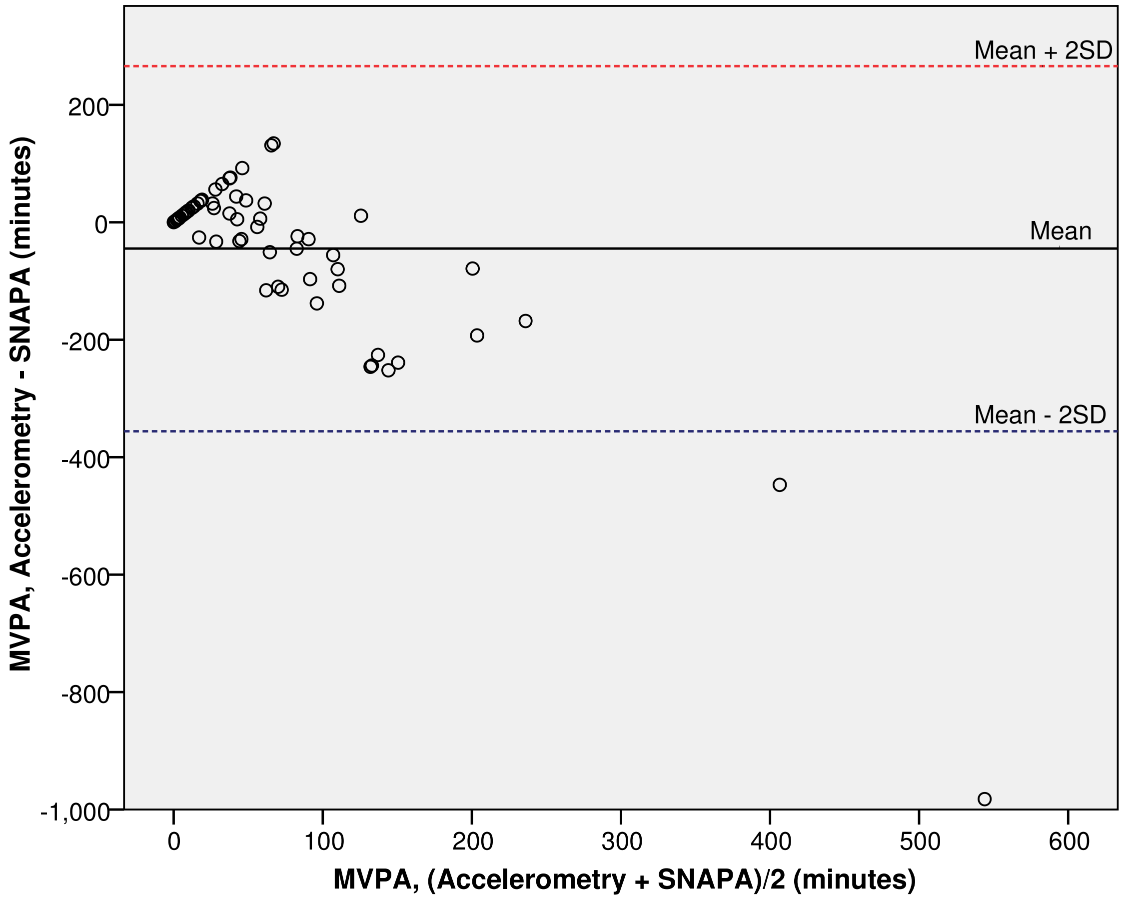
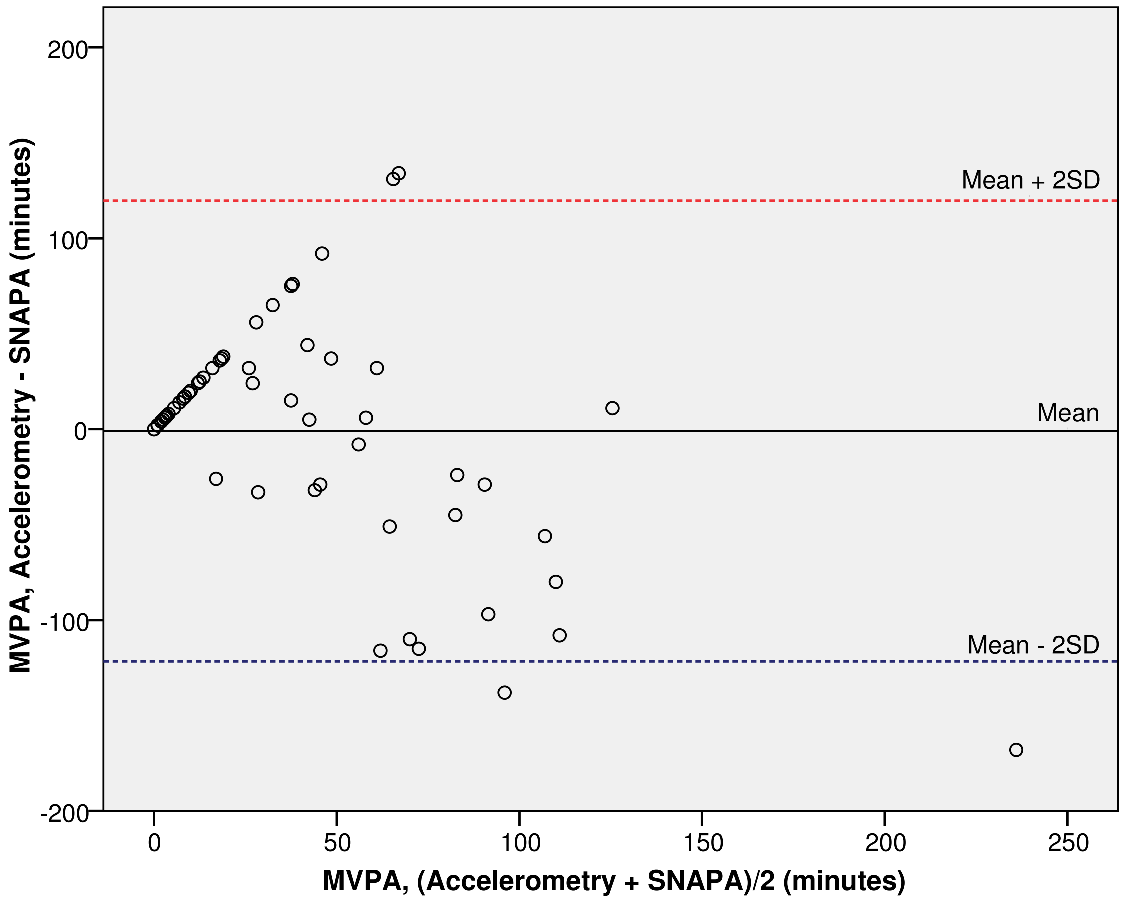


Figure 4.3 displays individual agreement between SNAPA™ and accelerometry using the Bland-Altman method for all participants. There was a mean bias of -45 minutes of moderate to vigorous physical activity, meaning that the mean amount of moderate to vigorous physical activity reported in SNAPA™ was greater than

that determined using accelerometry. The width of the limits of agreement were broad at ±310 minutes of moderate to vigorous physical activity; therefore 95% of participants could lie between an overestimation of 5 hours 55 minutes of moderate to vigorous physical activity, and a underestimation of 4 hours 25 minutes. There appears to be one outlier who has overestimated minutes of moderate to vigorous physical activity by nearly 1000 minutes using SNAPA™.

Figure 4.4 Bland-Altman plot of the mean difference between accelerometry and SNAPA™ determined minutes of moderate to vigorous physical activity (MVPA) versus the mean of the two measurements for the sample minus the over-reporters (n=57)



Individual agreement was also explored after the removal of the over-reporters, as was performed in earlier analysis (page 141), using the criteria described on page 140 (Figure 4.4). This resulted in mean bias close to zero and smaller limits of agreement; although, these would still be considered relatively broad for the measurement of this variable at approximately 2 hours.

SNAPA™ versus 24 hour MPR dietary interview

Three participants were excluded from the dietary method comparison analysis. When processing the data it was noticed that these participants only reported food items for one meal time using the SNAPA™ tool which resulted in very low intake values for the day (<200kcal), and it was assumed that they had mis-understood the instructions. Table 4.8 shows the sample characteristics of participants excluded from the dietary method comparison analysis.

Table 4.8 Sample characteristics of participants excluded from the diet method comparison analysis (n=3)

	Frequency (%)	**Mean (SD)**
Age (years)		34.5 (10.6)
BMI (kg/m^2)		29.4 (4.3)
Gender		
Female	3 (100.0%)	
Ethnicity		
White	3 (100.0%)	
Occupation		
Employed full time	2 (66.7%)	
Homemaker	1 (33.3%)	

SD = standard deviation

<u>Estimated portion sizes verses average portion sizes</u>

As described in chapter two, during the completion of SNAPA^{TM}, participants are asked to estimate how much of the food or drink they consumed using standard descriptions or measures specific to the food or drink selected. In order to evaluate the usefulness of asking for estimated portion sizes, data analysis was carried out using the estimated portion sizes, and then a second data analysis was carried out where the estimated portion sizes (regardless of the option chosen) were substituted by recent population average portion sizes for each food and drink for adults aged 19-64 years derived from recent National Diet and Nutrition Survey databases (Wrieden and Barton, 2006). Table 4.9 shows the mean and standard deviation values for the main outcome measures, percentage of energy from fat and number of portions fruit and vegetables, calculated from the data collected by SNAPA™ (using both portion size methods) and 24 hour MPR dietary interview.

Table 4.9 Dietary intake outcomes determined by SNAPA™ and the multiple pass recall dietary interview, Mean (SD)

	SNAPA™ (EPS)	SNAPA™ (APS)	MPR
Percentage energy from fat	30.5 (9.7)	32.3 (9.8)	34.0 (8.9)
Number of FV portions	3.3 (2.9)	3.3 (2.9)	4.9 (3.8)

SD = standard deviation, FV = fruit and vegetable, EPS = estimated portion size, APS = average portion size, MPR = multiple pass recall dietary interview

Correlations between SNAPA and multiple pass recall derived percentage of energy from fat were 0.46 (Bootstrapped 90% CI, 0.30 to 0.60) using estimated portion sizes and 0.48 (Bootstrapped 90% CI, 0.31 to 0.64) using average portion sizes. The correlation between methods for portions of fruit and vegetables was 0.42 (Bootstrapped 90% CI, 0.22 to 0.60) regardless of the portion size used during analysis.

Figure 4.5 Bland-Altman plot of the mean difference between multiple pass recall dietary interview (MPR) and Synchronised Nutrition and Activity Program for Adults (SNAPA™) (using estimated portion sizes) determined percentage of food energy from fat versus the mean of the two measurements (n=68)

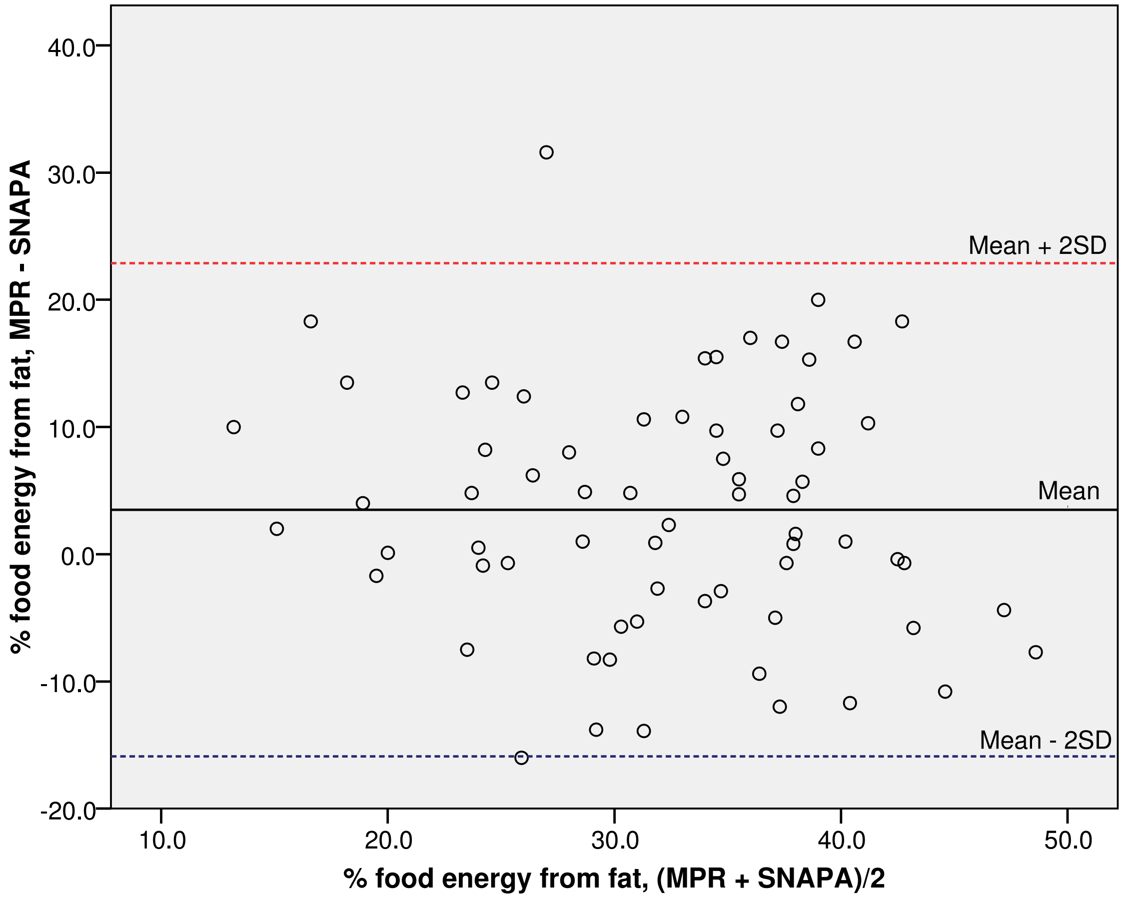
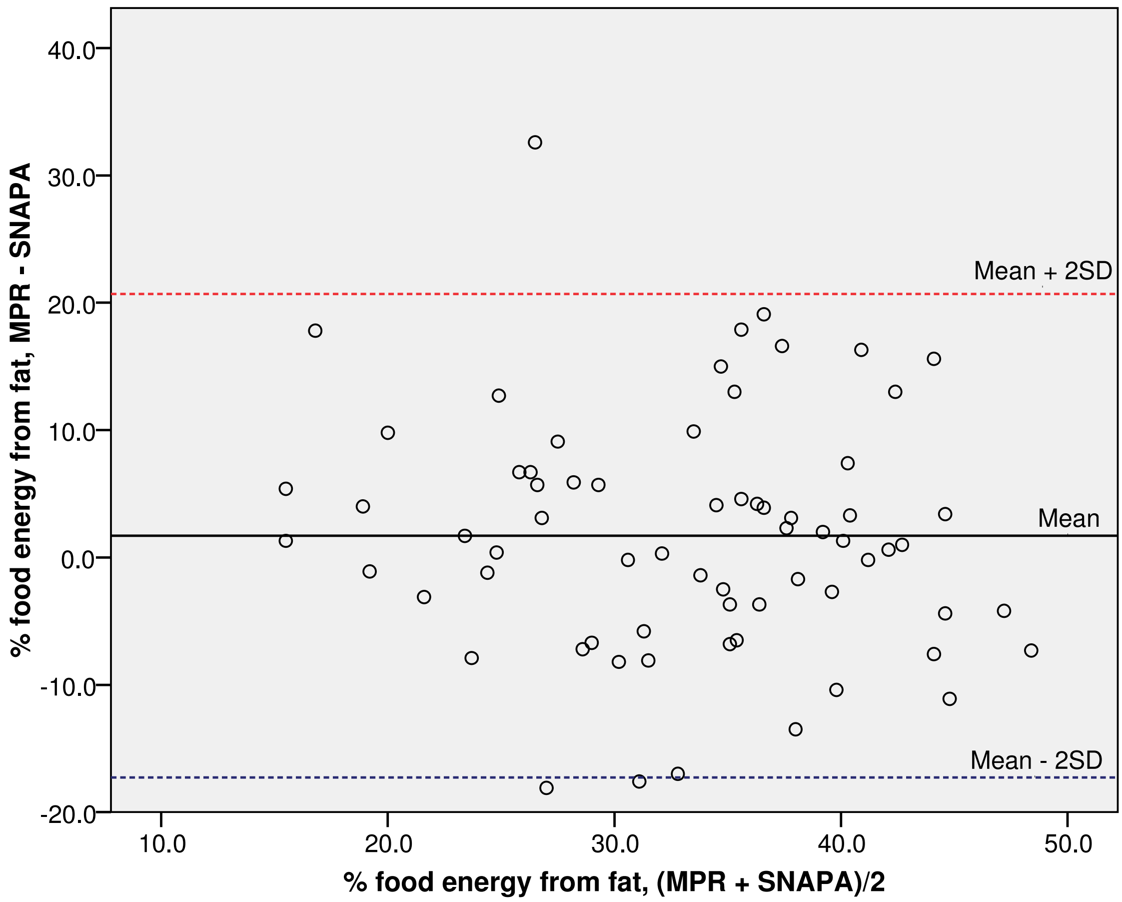


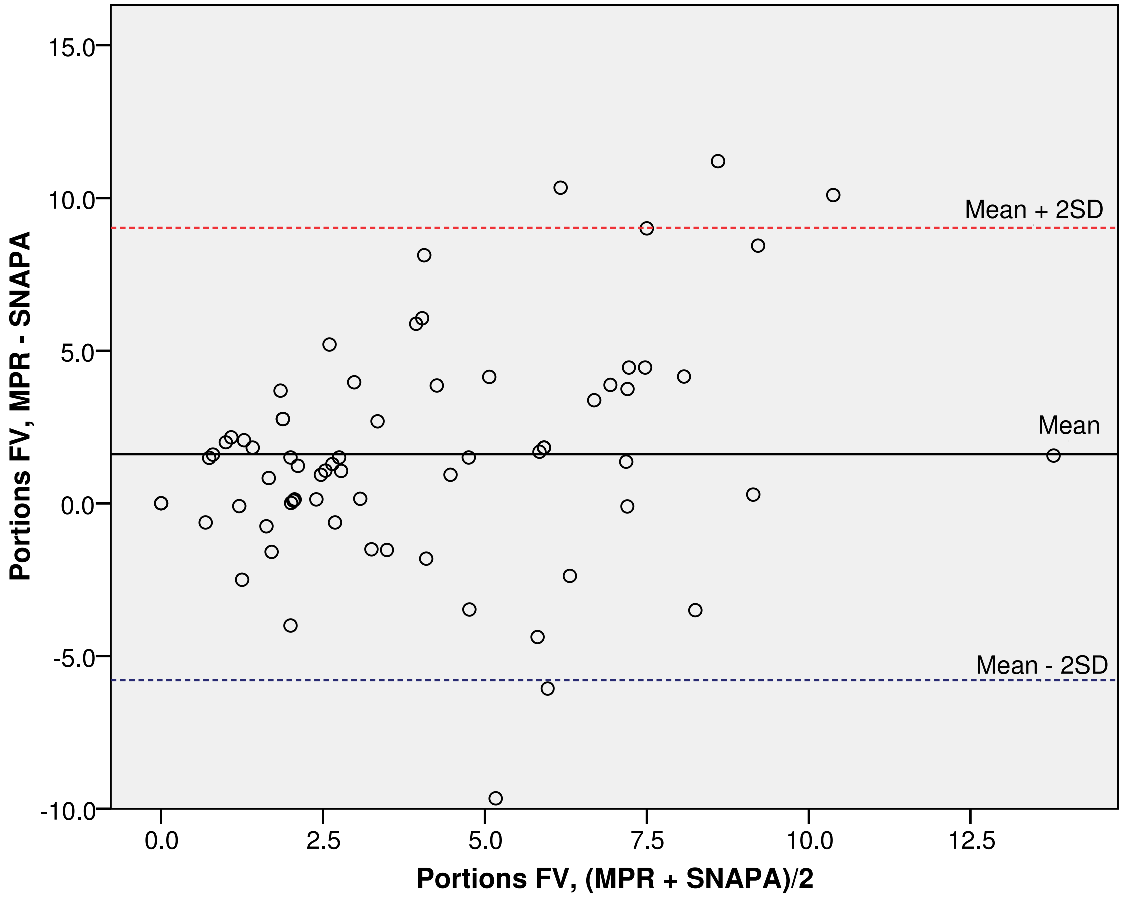
Figure 4.5 displays the Bland-Altman plot showing individual agreement between percentages of food energy from fat reported using SNAPA™ (using estimated portion sizes) and reported using the multiple pass recall dietary interview. There was a mean bias of 3.5%, indicating that the mean value of percentage of food energy from fat reported in SNAPA™ was lower than that reported in the multiple pass dietary interviews. The limits of agreement were relatively broad and 95% of participants could lie between an underestimation of 22.9% and an overestimation 15.9% of food energy from fat.

Figure 4.6 Bland-Altman plot of the mean difference between multiple pass recall dietary interview (MPR) and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) (using average portion sizes) determined percentage of food energy from fat versus the mean of the two measurements (n=68)



Individual agreement between the methods when average portion sizes were used to calculate percentage of food energy from fat from data collected by SNAPA™ is displayed in figure 4.6. The mean bias was slightly smaller (1.7%) compared with the estimated portion size method; however, the width of the limits of agreement was similar. Therefore, and 95% of participants could lie between an underestimation of 20.7% and an overestimation 17.3% of food energy from fat.

Figure 4.7 Bland-Altman plot of the mean difference between multiple pass recall dietary interview (MPR) and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined number of portions of fruits and vegetables versus the mean of the two measurements (n=68)



Finally, figure 4.7 displays the individual agreement between number of portions of fruits and vegetables reported using SNAPA™ and using the multiple pass recall dietary interview method. A mean bias of 1.6 portions was observed, indicating that SNAPA™ underreported fruit and vegetable intake in comparison with the multiple pass recall dietary interview. Again, the width of the limits of agreement was relatively large for this variable and 95% of participants could lie between an underestimation of 9 portions and an overestimation of 5.8 portions of fruits and vegetables. Estimations appear to less precise as the number of portions reported increases.

4.5. Discussion

The absence of systematic shifts in the mean for all three primary outcome variables in the repeated completions of SNAPA^{TM} indicates that there is no short-term learning or fatigue effect associated with repeat administrations of the SNAPA^{TM} tool. With respect to random measurement error, the typical errors for all three outcomes are of the order of one half of a between-subject standard deviation. This represents the noise in the measurement against which any intervention effect (signal) is to be detected in subsequent trials. Hence, the magnitude of the typical error indicates that the SNAPA^{TM} tool could be used to detect small to moderate effects with feasible sample sizes in subsequent trials. Similarly, the interclass correlation coefficients suggest acceptable relative reliability with moderate to large coefficients for the average of two measures. However, some caution is required as this is an estimate of reliability in the short-term; reliability would be expected to be affected over a longer period of time, for example equal to that of an intervention. Ideally, further evaluation work on SNAPA™ will include an investigation of long-term reliability.

The validity coefficients for the three primary outcomes are of the order of r=0.4. A correlation of 0.4 is equivalent to a standardised mean difference (Cohen's *d*) of 0.87 between-subject standard deviations – a moderate to large effect size. Therefore, the correlations observed indicate acceptable concurrent validity and are comparable with those observed typically for behavioural self-report tools of this type (Albanes *et al.*, 1990; Bingham *et al.*, 1994; Craig *et al.*, 2003; Matthews *et al.*, 2000; McMurray *et al.*, 1998; Ridley *et al.*, 2001; Trost *et al.*, 1999; Vereecken *et al.*, 2005; Welk *et al.*, 2004).

Comparisons of individual level agreement between SNAPA™ and the reference methods are difficult because most diet method comparison studies using this type of analysis report agreement for energy intake (for example Beasley *et al.*, 2005; Blanton *et al.*, 2006), and few physical activity assessment method comparison studies report individual level agreement. In the peas@tees study in children aged 9 and 10 years, the program underestimated minutes of moderate to vigorous physical activity compared with accelerometry by 21 minutes and 95% of the children could potentially overestimate time spent in moderate to vigorous physical activity by 2 hours 26 minutes, and underestimate by 1 hour 45 minutes (McLure *et al.*, 2009). The results from this study indicate that, at an individual level, SNAPA™ shows similar precision, after the removal of over-reporters from the analysis, when 95% of participants could over or underestimate minutes of moderate to vigorous physical activity by two hours. Overall bias existed for each variable (percentage food energy from fat; portions of fruits and vegetables and minutes of moderate to vigorous physical activity) and limits of agreement in each cases appear relatively broad.

Using portion size data estimated by the participants did not appear to increase the agreement between SNAPA™ and the multiple pass recall variables, and in the case of percentage energy from fat, agreement appeared to be closer when average portion sizes were used. It does, however, need to be noted that the actual weights of the food items were unknown, and that errors in portion size estimation will also have occurred in the multiple pass recall dietary interview. The estimated portion size question in SNAPA™ is very basic, asking participants to describe portion sizes in terms of appropriate household measures (e.g. teaspoon, ½ pint, mug); units (e.g. packet, slice) or simply describe a portion as small, medium or large. More sophisticated methods may be required to improve that accuracy of portion size estimation, and computer-based tools with detailed portion size estimation processes do exist (as described in chapter one). However, the purpose of SNAPA™ is to be a quick and low burden method and it was believed that the addition of complicated portion size estimation processes would increase completion time and burden. The removal of the portion size question is worth considering in any future revisions of SNAPA™ as using average portion sizes did not appear to affect the accuracy of the program. This would also result in lower burden for the participant, as currently this question is repeated each time a food item is reported.

A limitation of this study is that the SNAPA™ variables were compared against reference methods, rather than true criterion gold standards, therefore, errors will exist for the variables obtained by all of the assessment methods. As discussed in chapter one, the main limitations of accelerometry include the inability to accurately assess non-ambulatory activity (rowing, cycling); weight bearing activities and walking/running uphill; and water based and high impact activities (when monitor is removed). Another major limitation is that prevalence estimates are influenced markedly by choice of cut-point.

The 24 hour multiple pass recall dietary interview is limited as it is a self-reported, subjective method that suffers from memory, interviewer and social desirability bias (discussed in chapter one). Traditional 24hr recall methods tend to underestimate dietary intakes in western populations (Bingham *et al.*, 1995; Johansson *et al.*, 2001). The accuracy of the multiple pass recall dietary interview in adults is difficult to determine. Studies comparing multiple pass recall dietary interview with doubly-labelled water (Tran *et al.*, 2000) and monitored and controlled diets (Jonnalagadda *et al.*, 2000) have also shown underestimated intakes using this method. However, in two studies by Conway et al. (Conway *et al.*, 2003; Conway *et al.*, 2004) where the multiple pass recall dietary interview was compared with direct observation, it was found that there were no significant differences between actual and recalled intakes of energy, protein, carbohydrate or fat in adult men (Conway *et al.*, 2004), and that, as a population, adult women overestimated their energy and carbohydrate intakes by 8-10% and that recalled fat intake was not significantly different from actual intake in women across the BMI range studied (Conway *et al.*, 2003). As mentioned above, an additional limitation of the diet assessment reference method used in this study was that the true weights of foods and drinks reported were unknown. Participants did use aids to estimate portion size during the multiple pass recall dietary interview, however, although the food photography atlas has been shown to increase accuracy of portion size estimation (Nelson *et al.,* 1996), other studies using photographic and other aids, found no improvements in portion size estimations (Cypel *et al.*, 1997; Frobisher and Maxwell, 2003; Godwin *et al.*, 2006; Godwin *et al.*, 2004; Turconi *et al.*, 2005).

This study was not designed to measure habitual levels of dietary intake and physical activity, but simply to assess if the SNAPA™ outcome variables were similar to those obtained by the reference methods over the same time period. Further evaluation over a longer time period with multiple completions of SNAPA™

is needed to explore the ability of SNAPA™ to assess habitual or even individual level behaviours.

As discussed in chapter two, the ‘typical/normal’ day questions may be used as a screening tool if only minimal data, for example just one day of data, can be collected. However, if the results of this study are typical, and only about 50% of a sample report a normal day, a normal amount of food and/or drink consumed, and/or a normal amount of physical activity carried out, this would need to be taken into account when carrying out any sample size estimations.

4.6. Conclusion

The results of this preliminary validation study shows that SNAPA™ is a promising method for the assessment of dietary and physical activity behaviours at a group level, with acceptable levels of agreement with reference methods and test-retest reliability. More in-depth evaluation is now required using more accurate, objective reference methods (e.g. combined heart rate and accelerometry and dietary observation) to explore the accuracy of SNAPA™ further. In addition, this should include an exploration of the accuracy of SNAPA™ when completed over multiple days, as multiple days of data are required for the more precise measurement of habitual behaviours.

Chapter Five: Use in the Get a Better Life campaign

5.1. Introduction

Following the preliminary method comparison study, SNAPA™ was used to collect data on diet and physical activity behaviours in a study being carried out by researchers at Teesside University (and later Durham University). The Community Challenge Project was funded by the Food Standards Agency and aimed to evaluate the effectiveness of the public health campaign ‘Get a Better Life’ for increasing healthy eating behaviours and physical activity levels in adults living in Teesside. The campaign was launched in January 2008 and ended in October 2009. The project was transferred to Durham University in 2009 (full transfer process completed April 2009), due to the relocation of the Principal Investigator and majority of the research team to Durham University in October 2008. My role in this study was as the project manager and my exact contribution to the work is documented in the Preliminary section of this thesis.

For the purpose of this thesis, this chapter will concentrate on the data collection aspects of the project using SNAPA™, including a summary of the diet and physical activity findings and the practical issues identified when using SNAPA™ in a ‘live’, population wide situation.

5.2. Aim and Objectives

The aim of this study was to:

- Evaluate the effectiveness of a novel brief intervention based on psychological theories of health behaviour change for motivating adults on low-incomes to make beneficial changes to their diet (increase fruit and vegetable consumption and decrease consumption of high-fat food) and level of physical activity when compared with a traditional advice-giving approach through a community challenge.
- Evaluate the effectiveness of an online intervention for the promotion of healthy eating and levels of physical activity in adults living in the Tees Valley
- Explore the feasibility of using SNAPA™ in real world/research settings

The objectives of this study were to:

- Measure diet and physical activity variables of participants of the ‘Get a Better Life’ campaign at baseline and follow-up time points using SNAPA™.
- Quantify changes in dietary and physical activity variables from baseline to follow-up

5.3. Methods

5.3.1. Ethical approval

This study was approved by the Teesside University, School of Health and Social Care Research Ethics Committee, and by the Durham University School of Medicine and Health Research Ethics Committee after its transfer to Durham University (completed April 2009) (appendices T, U and V).

5.3.2. Overview of the Get a Better Life campaign

The ‘Get a Better Life’ (GABL) campaign was developed by researchers at Teesside and Durham University, along with key staff at Gazette Media Group, producers of the local ‘Evening Gazette’ newspaper. The campaign aimed to ‘challenge’ residents of the Tees Valley to make two ‘pledges’ (one food-related and one physical activity-related) based on the following three health behaviour categories:

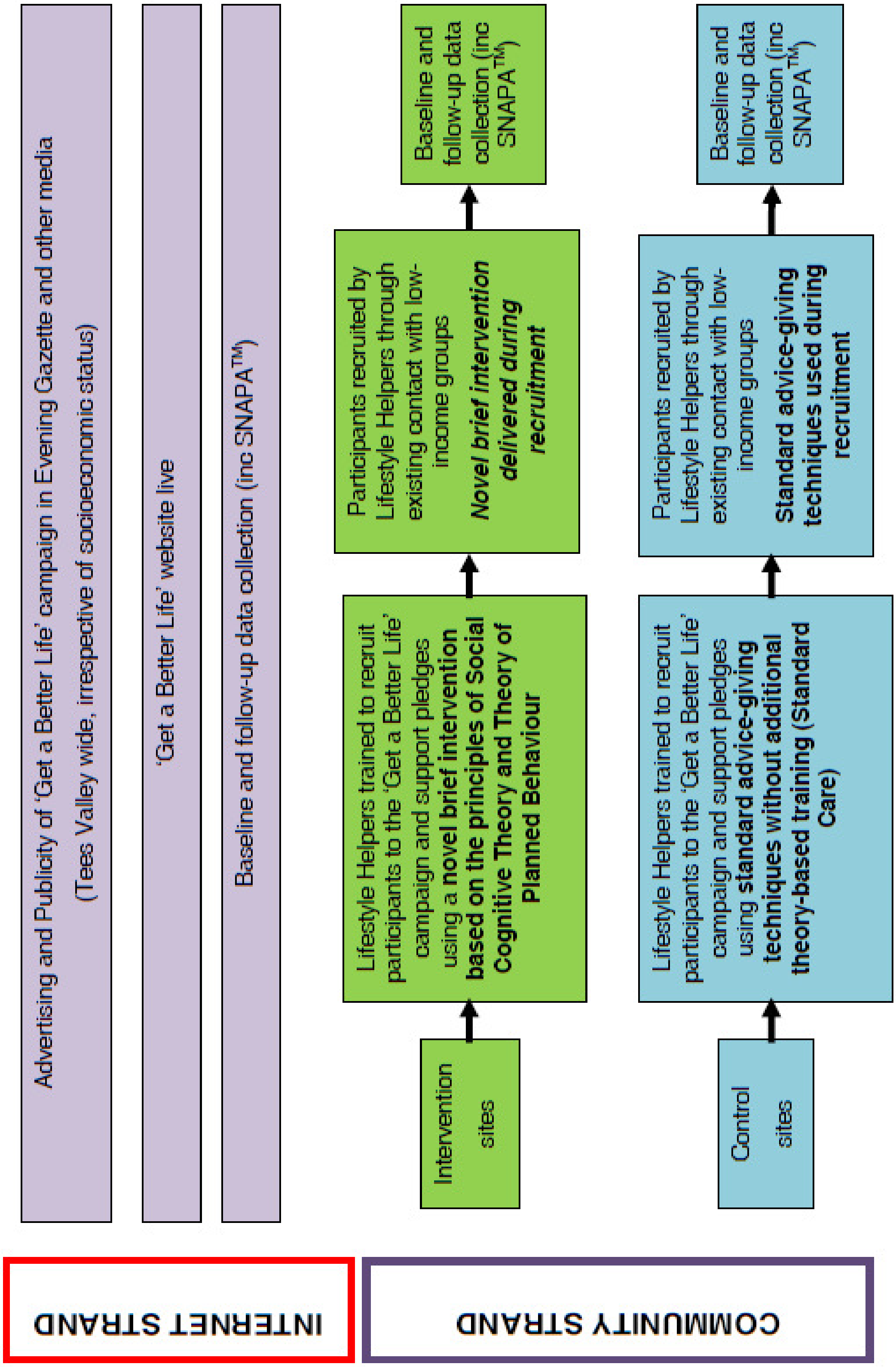
- Decrease dietary fat intake;
- Increase fruit and vegetable intake;
- Increase moderate-vigorous physical activity levels;

and to work towards their pledges for one year. These diet and physical activity variables were targeted as they correspond to the main diet and physical activity government recommendations for good health and the prevention of obesity (Department of Health, 1991; Department of Health, 1994; Department of Health, 1998; Department of Health, 2004; Cross-Government Obesity Unit *et al.*, 2008). The campaign consisted of two strands, one focused ‘community’ strand aimed particularly at those living in low socioeconomic areas of the Tees Valley, and a population wide ‘internet-based’ strand. The community strand was further divided into control and intervention groups where a novel brief intervention using brief negotiation/motivational interviewing techniques was compared against a brief intervention using traditional advice giving techniques, both delivered by local volunteers trained as GABL lifestyle helpers. The community and internet strands, therefore, differed in terms of recruitment method (face to face with a lifestyle helper as opposed to via the campaign website); support information delivery method (information booklets and newsletters as opposed to electronically on the campaign website); and data collection methods (measured by researcher as opposed to self-reported). Incentives were offered to all participants in the form of a support pack (containing a branded sports bag, t-shirt, water bottle, pedometer, pen, key-ring and trolley coin, along with a free JJB gym pass) received at baseline, and entry into a prize draw if follow-up data collection was completed. An overview of the Community Challenge Project is illustrated in figure 5.1. Further details of each strand of the campaign, along with full results, are described in forthcoming papers (appendices JJ and KK).

The community strand of the study followed a parallel group pre-post design using randomised matched-groups. Participants were assigned to the intervention group or an active control group dependent on the Public Health Locality (PHL) that they lived in. Lifestyle helpers were trained to recruit participants to GABL. Intervention lifestyle helpers delivered a novel, theory-based brief intervention (intervention group) during recruitment, while control lifestyle helpers used standard usual care, advice-giving techniques. The community strand also served as a way of encouraging and supporting low SES adults to take part in GABL by over-coming barriers such as limited I.T. access, lack of I.T. experience and low self-esteem.

The internet strand of the study followed an uncontrolled before-after study design, with all participants receiving the intervention of taking part in GABL via the campaign website. The main purpose of the internet strand of the campaign was to increase awareness of the campaign in order to aid recruitment to the community strand, which was the primary study of interest in the Community Challenge Project.

Figure 5.1 Overview of the 'Get a Better Life' campaign



5.3.3. Promotion

The GABL campaign was promoted through advertisements and features published in the local newspaper, the 'Evening Gazette', and the 'gazettelive' website (www.gazettelive.co.uk) to ensure public awareness of and engagement with the campaign. The campaign was launched in January 2008, which included a front page feature and feature stories published each day for a week. Between January 2008 and October 2009, the 'Get a Better Life' campaign had over 150 mentions in the Evening Gazette, including Tees Pride supplements, regular news, feature & Family Life stories and a dedicated gazettelive channel featuring a series of videos.

Figure 5.2 Examples of 'Get a Better Life' news stories published in the Evening Gazette

The GABL campaign, for recruitment to the community strand of the project in particular, was also promoted through posters and leaflets displayed in community centres, libraries, doctors surgeries, and health centres, as well as through active canvassing by research team members at community events and shopping centres. A minimum of two members of the research team would attend these canvassing sessions, where they would wear a 'Get a Better Life' T-shirt, position themselves with a project promotion board or stall; hand out goody bags containing project information sheets and a project pen, key ring and Frisbee; and answer any questions from members of the public about the campaign.

5.3.4. Recruitment and data collection sessions

Recruitment for the community strand of the GABL campaign took place between May and October 2008. Individuals interested in taking part in the community strand contacted the research team by telephone, email or directly during the active canvassing sessions. A consultation appointment was then arranged by a member of the research team. The majority of these sessions took place in the Life Store[3] (Middlesbrough Town Centre), but they also took place in participants' homes, at Teesside University or at local community centres/venues (with prior permission from the centre/venue manager). At the consultation participants were given the opportunity to ask any questions before consent was obtained (appendix W). An appropriately trained lifestyle helper (dependent on which study area the participant lived in) then delivered the brief intervention and baseline data was collected by one of the research team.

Another way that participants were recruited was through community groups, schools and workplaces. The project team not only actively contacted a number of these groups, but were also contacted spontaneously by some. A main contact was identified within the group or organisation. This contact usually took on a 'peer leader' role, and they would spread the word of the campaign to other group members and be the main contact point for the research team when arranging group consultation sessions. The research team and lifestyle helper(s) could then attend the appropriate setting for the group (e.g. community centre, workplace, school), deliver the intervention and collect baseline data from the whole group in one session. The intervention delivery and data collection was, however, done individually with each member of the group in a private room or area. This method of recruitment was particularly effective as a number of participants could be recruited in a short space of time.

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[3] The Life Store is run by NHS Middlesbrough and is a central service where people can 'drop in' for advice on any aspect of health and be signposted to any of the services within the NHS, as well as the voluntary sector and Middlesbrough Council, if appropriate. It is also the location for a number of structured services such as the Stop Smoking Service, Audiology Service, Baby Hearing Service, and local walking groups.

Prior to six and 12 month time-points, participants were contacted by the research team to arrange their six month and 12 month follow-up data collection sessions. The data collection sessions were carried out by a member of the research team. As with the initial consultation and baseline data collection sessions, follow-up data collection sessions were carried out in quiet, private settings either at the Life Store, the participants' home, Teesside University or a local community centre/venue, depending on the participant's preference.

The internet strand of the GABL campaign was delivered via the campaign website (www.getabetterlifecampaign.co.uk) between January 2008 and May 2009, with recruitment taking place between January and April 2008. People interested in the internet strand campaign were instructed to visit the website, which contained more information about the campaign. Those who wished to take part were then asked to register to the website, which included obtaining consent (appendix X); completing SNAPA™; and making their two pledges. Once a participant completed the registration process, full access to the GABL website was given using their unique username (email address) and password. The GABL website contained healthy eating and physical activity information to help participants achieve their pledges, along with recipes, news of local events, news stories relating to the GABL campaign and links to relevant nutrition, physical activity and other useful sites.

Participants were asked to complete SNAPA™ again at six and 12-months. Email reminders were sent to all participants when they reached each time point, along with reminder articles published in the Evening Gazette and on the Gazette Live website. Participants could access SNAPA™ at a time of their convenience via the campaign website using their username and password.

5.3.5. Completion of SNAPA™

In the community strand of the GABL campaign, participants completed SNAPA™ with the assistance of a researcher (acting as an interviewer) at their initial consultation and follow-up data collection appointments using a laptop which contained SNAPA™ on a local server. The use of SNAPA™ contained on a local server (i.e. contained within the laptop), eliminates the need for access to the internet and allows SNAPA™ to be used in any environment or setting. One of the main principles, and advantages, of SNAPA™ is that it is an internet-based tool and therefore can reach large numbers and be completed by users at their own time, in familiar locations. However, the requirement of the community strand of GABL was for a tool that could be used by the research team in the consultation settings, where internet availability was unknown. The advantages related to flexibility for self-completion offered by an internet setting were not required in this strand.

SNAPA™ was completed for a second time at each data collection time point via telephone with a researcher. Although SNAPA™ had not been validated when used either with assistance from a researcher, or with the extra variable of via the telephone, this method was most appropriate with this population. As already discussed, one of the purposes of the community strand was to allow people to take part in GABL without the need for internet access or IT skills and, in practice, it was clear that a number of the community participants did have low computer literacy. Therefore it was anticipated that participants would find self-completing SNAPA™ burdensome and time consuming (especially within the time constraints of the data collection sessions). In an attempt to achieve complete (and potentially more accurate) diet and physical activity data, SNAPA™ was ‘read aloud’ to the participant by the researcher, and the participant instructed which data were to be inputted. Obviously this approach is not ideal, and works against some of the features that theoretically give SNAPA™ an advantage over interviewer-based recalls (e.g. social desirability bias, interviewer associated biases), however it was believed that in this population, the method employed would, on balance, be more feasible and result in more complete and accurate data. It is an intended aim that future evaluation work will explore the use of SNAPA™ as an interviewer administered tool.

The original intention in this study was that each participant would sit down with a researcher and complete SNAPA™ together, on two different days at each data-collection time point. In practice, however, the research team found that arranging a second face-to-face session was extremely burdensome for both researcher and participant, and after a number of unattended sessions, it was decided that the second SNAPA™ (the only assessment carried out at the second data collection session) would be completed via the telephone. Again, I appreciate that this approach may have potentially added to the measurement error, and to what degree is unknown, as this approach for SNAPA™ was not evaluated in the pilot work; however other studies have found little difference between similar recall methods administered over the telephone when compared with in-person administration (Bogle *et al.*, 2001; Casey *et al.*, 1999; Tran *et al.*, 2000). The additional advantage of administering SNAPA™ via the telephone was that the recalls were not pre-arranged (participants were told that they would receive a phone call during the week following the in-person data collection session); therefore participants were unaware of the exact day they would be contacted, reducing the chance that they would change behaviour in anticipation of recall. However, preferred times for telephone contact were recorded at the in-person data collection session to increase convenience and compliance. Although participants could decline to recall at that time if the timing of the telephone call was inconvenient, this was rarely an issue.

In the internet strand of the GABL campaign, participants were instructed to complete SNAPA™ once at baseline (during the registration process), six months and 12 months (through reminder emails and news stories in the Gazette). This was done wherever the participant had internet access (for example, home, work, or library). The majority of participants completed SNAPA™ remotely (without the assistance of a researcher). Initially, support sessions were arranged in community venues with internet access where researchers were available to help people register and complete SNAPA™; however these were poorly attended, and were not repeated at the follow-up data collection time points.

5.3.6. Feedback questionnaire

All participants of the internet strand of the GABL campaign (completers and non-completers) were asked to complete a feedback questionnaire, which asked participants about their experience of many aspects of the campaign, including the completion of SNAPA™. The feedback questionnaire was created using Survey Monkey (www.surveymonkey.com) and was accessed and completed online (appendix Y). An email with a link to the questionnaire was sent to all participants.

No identifiable data were collected using the questionnaire, therefore responses were completely anonymous. Community participants also received a paper-pencil feedback questionnaire to complete; however, questions were more focused on the consultation sessions and facilitators/barriers to achieving pledges, rather than the data collection process and no questions were asked about SNAPA™.

5.3.7. Data analysis

The data collected by SNAPA™ were exported into Microsoft Access and processed as described in chapter two. For the calculation of daily fruit and vegetable portions, all fruit juice reported in one day was counted as one portion and all baked beans and other pulses reported were counted as one portion.

Community strand

Analysis was carried out using the mean value of each outcome variable from the two days collected. A screening criterion was applied to the physical activity data to remove unfeasible data before analysis to identify any changes between baseline and follow-up levels was performed. Over-reporters were defined as reporting greater than 480 minutes of moderate to vigorous physical activity (the approximate time, at the minimum threshold for moderate to vigorous physical activity of three metabolic equivalents (METs), to achieve a maximum sustainable physical activity level of 2.5 (Westerterp, 2001)). If a participant reported greater than 480 minutes of moderate to vigorous physical activity on just one day of the two recalled, that day was removed from the analysis and just one day of data was used for that participant.

Data were analysed using an analysis of covariance (ANCOVA) model, with the baseline scores as covariate to control for potential imbalances between groups at baseline. This model is generally more efficient than analysis of post scores only (ignoring baseline) or analysis of change scores (post minus pre). One primary comparison is the difference in the change in portions of fruit and vegetable (FV) consumption between the intervention and control at 12 months (given by the coefficient b, below), though the 6-month outcomes were also explored:

FV (12 months) = a + b·group (intervention, control) + c·baseline FV.

Number of portions of FV was treated as a continuous variable rather than a count, as it is based on multiples of portion size and may be fractional. This model adjusts for baseline imbalance and provides the between-group difference in the change in FV from baseline to follow-up. The same model was applied to the dietary fat and physical activity outcomes (the remaining primary comparisons). Given the substantial proportion of zero values and oddly-shaped distributions, confidence intervals were constructed via a criterion nonparametric bootstrapping method (Efron and Tibshirani, 1993). On each of 10000 resampling runs, *n* cases (given by the sample size) were randomly selected with replacement from within the original data (maintaining case correspondence). Each time, the mean difference (adjusted for baseline) between baseline and 6 months (or baseline and 12 months) was calculated and stored. The 90% confidence interval for the population mean difference was then derived by taking the 5^{th} and 95^{th} percentile of the 10000 stored differences (Resampling Stats v.4.0.7, Resampling Stats Inc., Arlington, Virginia).

Sample size estimation

The sample size estimation was matched explicitly to the intended analysis. To provide a more robust estimate of habitual behaviours and reduce noise in the measurement, participants were asked to complete two baseline and two post-intervention assessments. A correlation between baseline measures of 0.7, between follow-up measures of 0.7, and between baseline and follow-up of 0.5 was assumed (realistic, conservative estimates for self-report tools based on unpublished observations). For 90% power to detect the intervention effect of half a portion (2P = 0.05) the Stata® 'method ANCOVA' produced a required sample size of 189 participants in each group (based on a estimated population standard deviation of 2.01 portions taken from the National Diet and Nutrition Survey). An allowance for attrition of 30% inflates the target N to 270 participants in each arm.

It was recognised that in this community study individuals are not the unit of randomisation. Rather, two public health locality team areas are randomly allocated to each arm. Hence, theoretically there is some element of clustering.

This could not be accounted for post-study by multilevel modelling/ SAS Proc Mixed type procedures as there were insufficient number of clusters in each arm to estimate the variances. Data were therefore analysed at the individual level. A negligible intra-class correlation for this pragmatic community trial was assumed and hence no allowance was made for any design effect of clustering.

Internet strand

Basic descriptive statistics were carried out on the baseline, six month and 12 month diet and physical activity data for the whole sample, and for the sample who reported that the day recalled was a 'normal day'. The screening criterion was applied to the physical activity data as described above.

Comparison between baseline vs. 6-month and baseline vs. 12-month data was conducted using the same nonparametric bootstrapping method described above, based simply on the change from baseline to follow-up (equivalent to a paired t-analysis but more appropriate for badly behaved residuals).

A sample size estimation was not required for the internet strand of the GABL campaign, as this was not the primary study of interest. The primary purpose of the internet strand was to increase awareness of the campaign in order to aid recruitment to the community strand of the campaign.

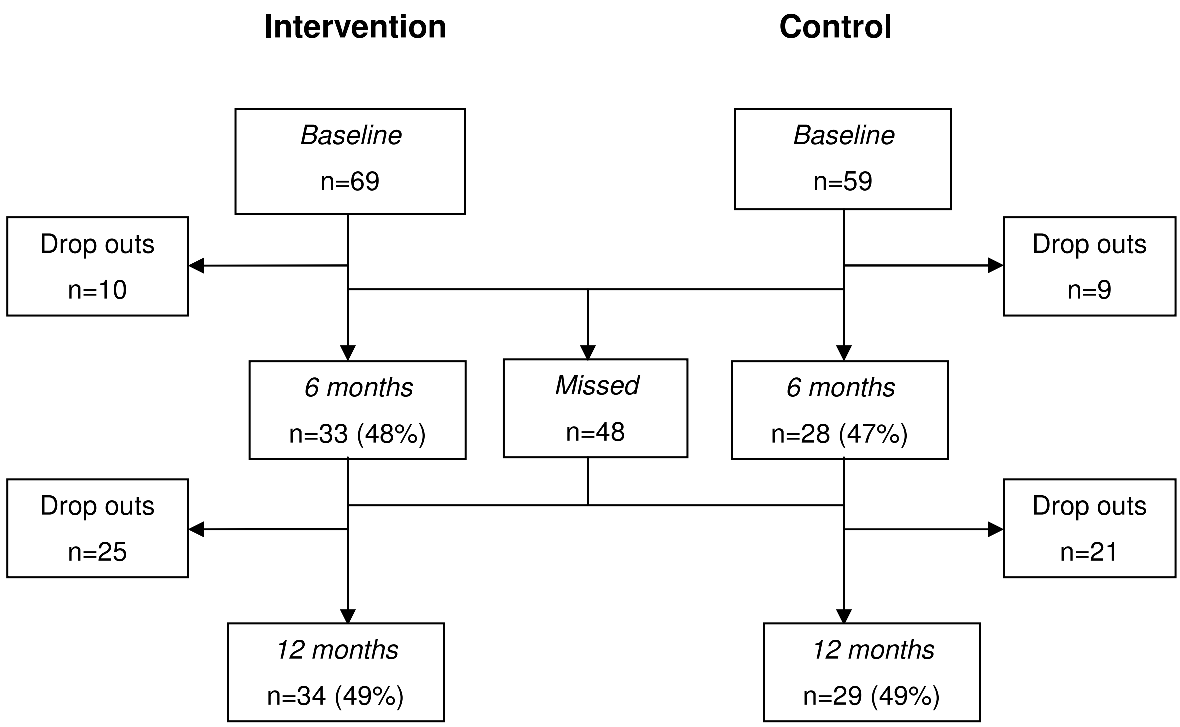
5.4. Results

5.4.1. Participant recruitment and characteristics

Community strand

Figure 5.3 displays the flow of participants in the community strand of the GABL campaign. A total of 128 people were recruited at baseline, just 24% of the desired sample size. Retention rates were similar in both control and intervention groups, and at each follow-up data collection time point (between 47% and 49%). Therefore attrition rates were approximately 50% and greater than anticipated (30%).

Figure 5.3 Recruitment and retention flowchart for the community strand of the 'Get a Better Life' campaign



The sample characteristics of the participants who completed each data collection time period are displayed in table 5.1. The mean age of participants in each group ranged from 41.6 to 49.1 years of age, throughout the data collection periods. The control group contained a greater proportion of men than the intervention group, consistently over the year. This was probably because of the number of male participants who were recruited through the workplace, Corus Steel, located in one of the control areas.

Table 5.1 Sample characteristics of participants in the community strand of the 'Get a Better Life' campaign at baseline and follow-up

	Baseline		6 months		12 months	
	C (n=59)	I (n=69)	C (n=28)	I (n=32)	C (n=29)	I (n=34)
Mean (range)						
Age (years)	45.6 (19-79)	41.7 (16-70)	43.6 (19-73)	41.6 (17-66)	49.1 (21-73)	42.8 (17-70)
Number of Participants (%)						
Gender						
Female	37 (62.7)	59 (85.5)	17 (60.7)	29 (90.6)	19 (59.4)	32 (94.1)
Male	22 (37.3)	10 (14.5)	11 (39.3)	3 (9.4)	10 (31.3)	2 (5.9)
Ethnicity						
White	53 (89.8)	56 (81.2)	25 (89.3)	28 (87.5)	29 (85.3)	
Other	3 (5.1)	4 (5.8)	3 (10.7)	1 (3.1)	1 (3.1)	2 (5.9)
Not reported	3 (5.1)	9 (13.0)	-	3 (9.4)	3 (10.3)	3 (8.8)
Education						
University degree, postgraduate degree	5 (8.5)	14 (20.3)	4 (5.8)	6 (18.8)	5 (17.2)	9 (26.5)
Further education, A/AS level, Diploma	26 (44.0)	23 (33.3)	14 (50.0)	10 (31.2)	14 (48.3)	9 (26.5)
Secondary School, GCSE	22 (37.3)	21 (30.4)	10 (35.7)	12 (37.5)	10 (34.5)	12 (35.3)
Not reported	6 (10.2)	11 (16.0)	-	4 (12.5)	-	4 (11.7)

**Black Caribbean, Indian, Pakistani, Filipino*

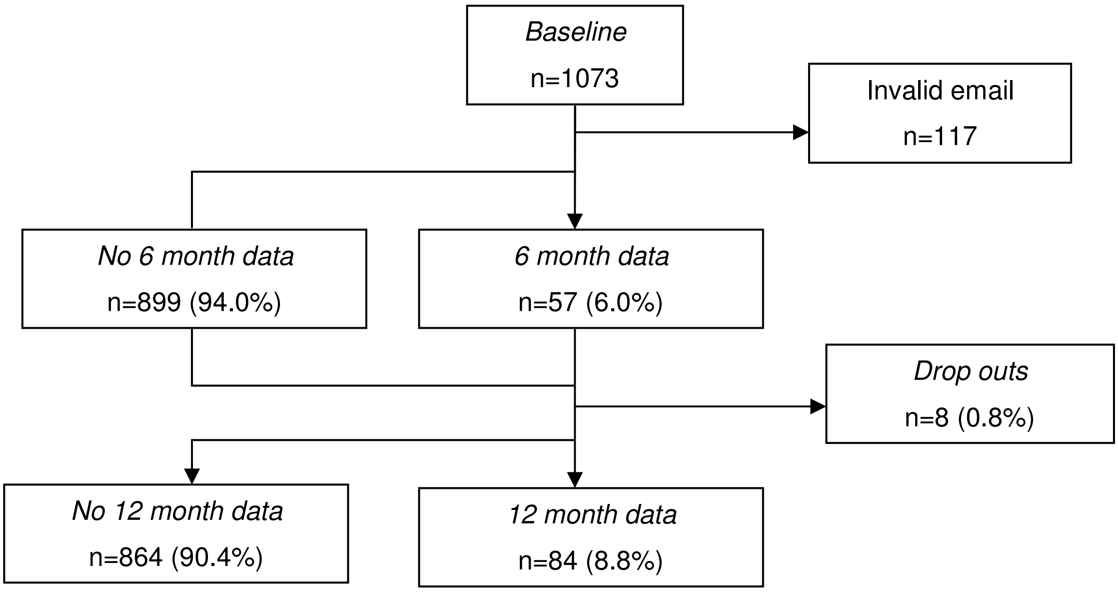
Table 5.1 (continued) Sample characteristics of participants in the community strand of the Get a Better Life campaign at baseline and follow-up

	Baseline		6 months		12 months	
	C (n=59)	I (n=69)	C (n=28)	I (n=32)	C (n=29)	I (n=34)
Number of Participants (%)						
Employment						
Employed Full Time	22 (37.3)	26 (37.7)	14 (50.0)	10 (31.3)	14 (43.8)	14 (41.2)
Employed Part Time	4 (6.8)	10 (14.5)	5 (17.9)	6 (18.8)	3 (9.4)	4 (11.8)
Full Time Education	1 (1.7)	4 (5.8)	1 (3.6)	1 (3.1)	-	1 (2.9)
Retired	12 (20.3)	6 (10.2)	4 (14.3)	2 (6.3)	8 (25.0)	3 (8.8)
Unemployed	10 (16.9)	5 (7.2)	3 (10.7)	4 (12.5)	2 (6.3)	2 (5.9)
Voluntary Worker	4 (6.8)	-	1 (3.6)	-	2 (6.3)	-
Homemaker	2 (3.4)	6 (8.7)	-	4 (12.5)	-	5 (14.7)
Self-employed	-	3 (4.3)	-	2 (6.3)	-	2 (5.9)
Full Time Carer	1 (1.7)	-	-	-	-	-
Not reported	3 (5.1)	9 (13.0)	-	3 (9.4)	-	3 (8.8)

Internet strand

Figure 5.4 displays the flow of participants in the internet strand of the GABL campaign. A total of 1073 people were recruited to the campaign via the campaign website; however when follow-up contact was made 117 of the email addresses provided proved to be invalid leaving 956 participants remaining. Retention rates were very low with only 6% and 9% of the 956 participants providing six month and 12 month data, respectively. Only eight internet participants actively dropped out of the campaign (contacting the research team via email or telephone and asking to be removed from the study and any contact lists). The 864 participants who did not complete the six or 12 month data collection time point were classed as 'passive' drop outs.

Figure 5.4 Recruitment and retention flowchart for the internet strand of the 'Get a Better Life' campaign



The sample characteristics of the internet participants at each stage of the campaign are displayed in table 5.2. The mean of age the participants remained in the early forties (40.2 to 43.5 years), throughout the study period, and the proportion of women participants remained fairly consistent at approximate 2/3 of the sample. The proportion of participants with a University or postgraduate degree increased from 25% at baseline to 46% at both 6 and 12 month follow-up, where as the proportion of participants whose highest education was at secondary school or GCSE level, decreased from 43% at baseline to 19% and 21% at 6 and 12 months follow-up, respectively. There do not appear to be any other large variations in any of the other characteristics from baseline to follow-up.

Table 5.2 Sample characteristics of participants in the internet strand of the 'Get a Better Life' campaign at baseline and follow-up

	Baseline (n=1073)	6 months (n=57)	12 months (n=84)
Mean (range)			
Age (years)	40.2 (16-91)	43.5 (18-73)	43.0 (17-73)
Number of participants (%)			
Gender			
Male	315 (29.4)	19 (33.3)	25 (29.8)
Female	753 (70.2)	37 (64.9)	58 (69.0)
Not reported	5 (0.5)	1 (1.8)	1 (1.2)
Employment			
Employed Full-Time	515 (48.0)	33 (57.9)	48 (57.1)
Employed Part-Time	153 (14.3)	7 (12.3)	13 (15.5)
Self-Employed	43 (4.0)	2 (3.5)	1 (1.2)
Unemployed	179 (16.7)	5 (8.8)	9 (10.7)
Homemaker	120 (11.2)	8 (14.0)	10 (11.9)
Full-Time Education	47 (4.4)	1 (1.8)	1 (1.2)
Full-Time Carer	16 (1.5)	1 (1.8)	2 (2.4)
Ethnicity			
White	1044 (97.3)	55 (96.4)	84 (100.0)
Other *	29 (2.7)	2 (3.6)	0 (0.0)
Education			
University degree, Postgraduate degree	264 (24.6)	26 (45.6)	39 (46.4)
Further education, A/AS level, Diploma	349 (32.5)	20 (35.1)	27 (32.2)
Secondary School, GCSE	460 (42.9)	11 (19.3)	18 (21.4)

** Black African, Black Caribbean, Chinese, Indian, Pakistani, Asian other, Middle Eastern, Lebanese, Mexican*

5.4.2. Diet and physical activity behaviours at baseline data

For the purpose of this thesis, the baseline results of the GABL campaign provided an example of the ability of SNAPA™ to collect cross-sectional data of reasonably large samples in different conditions. The baseline populations of GABL were the largest samples to have completed SNAPA™ to date. Although these participants could not be considered representative of all adults living in the Tees Valley, the data provides an interesting 'snap shot' of two sub samples of this population for comparison against previous national and regional data.

Community strand

At baseline, participants' fat and fruit and vegetable intakes were similar in the control and intervention groups (table 5.3). Overall, the point estimates of the percentage of food energy from fat were lower in this sample than national averages of approximately 35% (mean values of 35.8% for men and 34.9% for women; median values of 36.0% for men and 34.7% for women) (Henderson *et al.*, 2003). Mean values for numbers of fruit and vegetable portions were slightly higher than the national mean value of 2.8 portions (2.7 portions for men and 2.9 portions for women), although median values were similar to the national median value of 2.3 portions (2.2 portions for men and 2.4 portions for women) (Henderson *et al.*, 2002).

Table 5.3 Baseline diet behaviours in the community strand of the 'Get a Better Life' campaign

		Control (n=59)	Intervention (n=69)	All (n=128)
% food energy from fat	*Mean (SD)*	33.9 (8.2)	33.1 (8.1)	33.4 (8.1)
	Median (range)	34.7 (17.8-52.7)	34.1 (14.3-51.7)	34.3 (14.3-52.7)
Number FV portions	*Mean (SD)*	3.3 (3.0)	3.0 (2.4)	3.2 (2.7)
	Median (range)	2.5 (0-12)	2.5 (0-11.7)	2.5 (0-12)

SD = standard deviation, FV = fruit and vegetable

For the physical activity data collected by SNAPA™, there was only one instance where a participant (control) reported carrying out more than 480 minutes of moderate to vigorous physical activity on one day. This day of data was removed from the analysis and only one day of data was used for this participant.

Physical activity levels did differ substantially between groups in terms of mean minutes of moderate to vigorous physical activity, with the intervention participants reporting approximately 13 minutes of moderate to vigorous physical activity per

Table 5.4 Baseline physical activity behaviours in the community strand of the 'Get a Better Life' campaign

		Control (n=59)	Intervention (n=69)	All (n=128)
Minutes MVPA	*Mean (SD)*	29 (39)	42 (64)	36 (54)
	Median (range)	15 (0-180)	15 (0-330)	15 (0-330)
% ≥30 minutes MVPA		42.4	43.5	43.0

SD = standard deviation, MVPA = moderate to vigorous physical activity

day more than control participants. However, if median values were compared, there was no difference between the groups (table 5.4). The physical activity data reported was highly skewed in the direction of 0, with just a couple of high values affecting the mean, therefore using the median value for this data may be more appropriate.

The mean minutes of moderate to vigorous physical activity per day for the whole sample reported using SNAPA™ was 36 minutes. Averages of daily minutes of moderate to vigorous physical activity recorded in the Health Survey for England by accelerometry were 31 minutes for men and 24 minutes for women, although these decreased to 11 minutes for men and 8 minutes for women, when the 10+ minute bout criteria were applied (Craig *et al.*, 2009). Although direct comparisons can not strictly be made between these data, as different methods and durations of measurement were used, some indication of the performance of SNAPA™ is provided. Although the physical activity level reported in SNAPA™ may be higher than expected, the values do not appear to be unrealistic. When median values are used, levels reported using SNAPA™ may be considered closer to expected values.

The percentage of the sample reporting 30 minutes or more moderate to vigorous physical activity on average over the two days of data collection was relatively high, at 43%, compared with percentages meeting the 'at least five a week' recommendation based on Health Survey for England self-reported data (39% of men and 29% of women) (Craig *et al.*, 2009). Again, this is a loose comparison as different criteria have been applied and Health Survey for England data is based on data collected for a longer time period. The percentage of GABL community participants with an average 30 minutes or more of moderate to vigorous physical activity may have been lower if more days of data were collected.

The top five most popular food items reported were tea, vegetables, sandwiches, fruit and water (table 5.5). Although the exact rankings are different from those observed in the National Nutrition and Diet Survey (NDNS) (Henderson *et al.*, 2002), the proportion of participants reporting the top foods is similar. The biggest exception is that 92% of respondents in the NDNS reported eating savoury sauces, pickles, gravies and condiments, whereas in the community strand of the GABL campaign the highest reported food item to fit this category was mayonnaise, with only 9.4% of participant reporting consuming this item. This difference may be partly due to the categorisation of these foods items (in the NDNS several items are combined as one food category, in SNAPA™ each is listed individually), however none of these food items were highly ranked so this possibly identifies a weakness in that SNAPA™ does not probe for the recall of these items.

Another highly ranked food item in the NDNS was white bread (91% of responders). Bread was only reported by 24% of community GABL participants; however, the composite food item ‘sandwich’, which was one of the highest reported items (a food item not used in the NDNS), will include white bread.

Table 5.5 Top 50 food items reported by participants in the community strand of the 'Get a Better Life' campaign

Food item	n	%
Tea	84	65.6
Vegetables	79	61.7
Sandwich	70	54.7
Fruit	67	52.3
Water	62	48.4
Coffee	56	43.8
Cereal	54	42.2
Potatoes	52	40.6
Biscuits	46	35.9
Toast	44	34.4
Fizzy drinks (any flavour)	43	33.6
Yogurt	38	29.7
Fruit juice (any flavour)	37	28.9
Chips	35	27.3
Cake	32	25.0
Bread, sliced	31	24.2
Chicken/turkey	30	23.4
Chocolate	29	22.7
Crisps (any flavour)	29	22.7
Squash (any flavour)	27	21.1
Fish, white	25	19.5
Cheese	22	17.2
Sausage	22	17.2
Eggs	20	15.6
Bread roll	19	14.8
Wine	19	14.8
Baked beans	17	13.3
Bacon	16	12.5
Milk	16	12.5
Beef	15	11.7
Ham	15	11.7
Rice	15	11.7
Pastry	13	10.2
Soup	13	10.2
Yorkshire pudding	13	10.2
Mayonnaise	12	9.4
Pasta	12	9.4
Sweets (not chocolate)	12	9.4
Curry	11	8.6
Lager	11	8.6
Cereal bar	10	7.8
Fish, oily	10	7.8
Sugar	10	7.8
Tomato ketchup	10	7.8
Burger (including bun)	9	7.0
Pizza	9	7.0
Porridge	9	7.0
Ice cream (any flavour)	8	6.3
Muesli	8	6.3
Parmesan (Parmo)	8	6.3
Pie (savoury)	8	6.3

Table 5.6 Activities reported by participants in the community strand of the ‘Get a Better Life’ campaign (n=128)

Activity	n	%
Walking	84	65.6
Household tasks	46	35.9
Shopping	15	11.7
Gardening	12	9.4
Aerobics	9	7.0
Looking after children	8	6.3
DIY	6	4.7
Cycling	4	3.1
Running/Jogging	7	5.5
Swimming	3	2.3
Construction work	2	1.6
Dancing	2	1.6
Exercises – callisthenics	2	1.6
Pilates	2	1.6
Playing computer games – active	2	1.6
Sitting talking, reading, writing, typing	2	1.6
Watching TV/DVD	2	1.6
Weight training	2	1.6
Yoga	2	1.6
Bowling	1	0.8
Playing computer games – sitting	1	0.8
Roller blading	1	0.8
Snooker	1	0.8
Standing manual work	1	0.8

Activities not reported: Driving a car; working on a computer; cooking; reading; sleeping/napping; sexual activity; listening to music; talking on the telephone; arts and crafts; riding in a car/bus; standing (reading, talking, filing); badminton; football/kick around; writing; playing a musical instrument; golf; standing quietly; watching a film at cinema; basketball; gymnastics; horse riding; rock climbing; carpentry; darts; driving a lorry, tractor, bus; hockey; netball; riding a motorcycle; cricket; fishing; forestry; self-defence; sitting (operating machinery); squash; table tennis; tennis; water sports; baseball; bowls; farming; ice skating; judo; karate; kick boxing; rounders; rugby; skateboarding; skiing; snowboarding; tae kwan do

Internet strand

The baseline sample of the internet strand of the GABL campaign was reasonably large thus allowing some exploration of sub groups; in this case, gender differences.

Nearly 75% of the participants who signed up to the internet strand of the Get a Better Life campaign, reported that the previous day was a normal day (figure 5.5). Excluding those participants who did not report that the previous day had been normal made very little difference to the diet and physical activity outcomes (tables 5.7 and 5.8). Group averages of percentage of food energy from fat and fruit and vegetable portions were lower than those reported in the community

Figure 5.5 Normal day responses from participants in the internet strand of the 'Get a Better Life' campaign

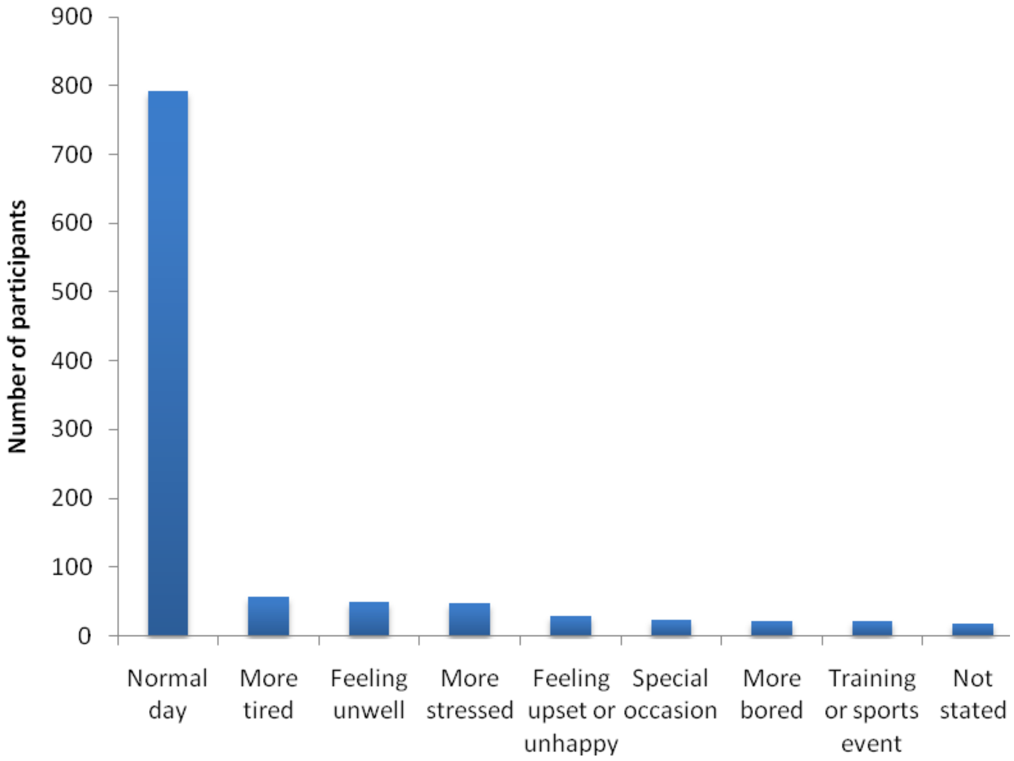


Table 5.7 Baseline diet behaviours in the internet strand of the 'Get a Better Life' campaign

		Men (n=277)*	Women (n=684)*	Total (n=966)
% food energy from fat	*Mean (SD)*	32.5 (13.3)	31.1 (12.2)	31.7 (12.6)
	Median (range)	33.3 (0-73.3)	32.0 (0-70.6)	32.4 (0-73.3)
Number FV portions	*Mean (SD)*	1.4 (1.9)	1.7 (2.1)	1.7 (2.4)
	Median (range)	1.0 (0-10.3)	1.0 (0-16.0)	1.0 (0-16.0)
Normal day responders		Men (n=205)*	Women (n=530)*	Total (n=740)
% food energy from fat	*Mean (SD)*	32.9 (13.3)	31.0 (12.2)	31.5 (12.5)
	Median (range)	34.0 (2.4-73.3)	32.0 (0-70.6)	32.1 (0-73.3
Number FV portions	*Mean (SD)*	1.5 (2.0)	1.7 (2.2)	1.6 (2.1)
	Median (range)	1.0 (0-10.3)	1.0 (0-16.0)	1.0 (0-16.0)

** gender not reported for 5 participants in total sample*
SD = standard deviation, FV = fruit and vegetable

strand (table 5.3), and lower than national averages (Henderson *et al.*, 2002; Henderson *et al.*, 2003).

When data collected for all participants were analysed, the group mean of minutes of daily moderate to vigorous physical activity was higher for women than men, however a larger proportion of women were classified as over-reporters (3.4% women verses 1.7% men) and when over-reporters were excluded from the analysis, men reported 6 more minutes of daily moderate to vigorous physical activity than women. Median values were zero minutes of moderate to vigorous physical activity per day for all analyses, demonstrating the skew of the data towards zero as seen in the community strand. After the exclusion of over-reporters, the group mean for daily minutes of moderate to vigorous physical activity for men and women combined was similar to that of the community participants (34 minutes for the internet participants, 36 minutes for the community participants).

Table 5.8 Baseline physical activity behaviours for the internet strand in the 'Get a Better Life' campaign

		Men (n=242)*	Women (n=622)*	Total (n=869)
Minutes MVPA	*Mean (SD)*	48 (130)	53 (153)	53 (147)
	Median (range)	0 (0-890)	0 (0-1340)	0 (0-1340)
% ≥30 minutes MVPA		20.7	18.8	19.7
Excluding over-reporters		Men (n=238)*	Women (n=601)*	Total (n=844)
Minutes MVPA	*Mean (SD)*	37 (94)	31 (87)	34 (92)
	Median (range)	0 (0-450)	0 (0-480)	0 (0-480)
Normal day responders, excluding over-reporters		Men (n=183)*	Women (n=467)*	Total (n=654)
Minutes MVPA	*Mean (SD)*	36 (90)	31 (85)	34 (90)
	Median (range)	0 (0-450)	0 (0-475)	0 (0-475)

** gender not reported for 5 participants in total*
SD = standard deviation, MVPA = moderate to vigorous physical activity

Table 5.9 Top 50 food items reported by participants in the internet strand of the 'Get a Better Life' campaign

Food item	Men (n=277)*		Women (n=684)*		Total (n=966)	
	n	%	n	%	n	%
Tea	104	37.5	280	40.9	384	39.8
Breakfast cereal	82	29.6	233	34.1	318	32.9
Sandwich	94	33.9	184	26.9	280	29.0
Coffee	68	24.5	193	28.2	262	27.1
Water	52	18.8	157	23.0	209	21.6
Vegetables	48	17.3	140	20.5	189	19.6
Fruit	43	15.5	141	20.6	185	19.2
Chicken/turkey	51	18.4	106	15.5	158	16.4
Toast	52	18.8	99	14.5	151	15.6
Potatoes	35	12.6	106	15.5	141	14.6
Fizzy drinks (any flavour)	28	10.1	98	14.3	126	13.0
Fruit juice (any flavour)	21	7.6	87	12.7	110	11.4
Biscuits	28	10.1	77	11.3	106	11.0
Chips	29	10.5	70	10.2	99	10.2
Bread, sliced	27	9.7	68	9.9	95	9.8
Crisps (any flavour)	25	9.0	70	10.2	95	9.8
Yogurt	11	4.0	70	10.2	81	8.4
Chocolate	14	5.1	66	9.6	80	8.3
Pasta	19	6.9	56	8.2	76	7.9
Baked beans	28	10.1	43	6.3	71	7.3
Soup	12	4.3	55	8.0	67	6.9
Bacon	22	7.9	43	6.3	65	6.7
Cake	14	5.1	49	7.2	63	6.5
Eggs	18	6.5	45	6.6	63	6.5
Porridge	11	4.0	52	7.6	63	6.5
Beef	17	6.1	45	6.6	62	6.4
Squash (any flavour)	21	7.6	40	5.8	61	6.3
Wine	13	4.7	36	5.3	49	5.1
Cheese	10	3.6	38	5.6	48	5.0
Curry	16	5.8	32	4.7	48	5.0
Fish, white	14	5.1	31	4.5	46	4.8
Bread roll	11	4.0	34	5.0	45	4.7
Yorkshire pudding	11	4.0	34	5.0	45	4.7
Sausage	13	4.7	27	3.9	40	4.1
Cereal bar	7	2.5	28	4.1	35	3.6
Rice	6	2.2	29	4.2	35	3.6
Pizza	8	2.9	24	3.5	32	3.3
Fish, oily	7	2.5	24	3.5	31	3.2
Gravy	8	2.9	23	3.4	31	3.2
Cottage pie	8	2.9	22	3.2	30	3.1
Lager	19	6.9	11	1.6	30	3.1
Milk	0	0.0	20	2.9	27	2.8
Burger (including bun)	6	2.2	19	2.8	25	2.6
Stew	2	0.7	22	3.2	24	2.5
Hot chocolate	3	1.1	20	2.9	23	2.4
Pie (savoury)	9	3.2	13	1.9	22	2.3
Ham	6	2.2	15	2.2	21	2.2
Lasagne	4	1.4	17	2.5	21	2.2

** gender not reported for 5 participants*

The top five reported food items were tea, breakfast cereal, sandwiches, coffee and water (table 5.9). There do appear to be some gender differences in the types of foods eaten. A higher proportion of women than men reported yogurt, fruit, fruit juice, chocolate and porridge, and a higher proportion of men than women reported sandwiches, baked beans, squash and lager. Results from the NDNS also suggest that yogurt and some fruits are more likely to be eaten by women than by men, and that baked beans and lager are more likely to be consumed by men than by women (Henderson *et al.*, 2002).

Table 5.10 Top 20 activities reported by participants in the internet strand of the 'Get a Better Life' campaign

Activity	Men (n=242)*		Women (n=622)*		Total (n=864)	
	n	%	n	%	n	%
Walking	120	49.6	290	46.6	410	47.5
Housework	54	22.3	327	52.6	381	44.1
Watching TV/DVD	42	17.4	104	16.7	146	16.9
Driving a car	45	18.6	98	15.8	143	16.6
Working on a computer	27	11.2	69	11.1	96	11.1
Looking after children	12	5.0	78	12.5	90	10.4
Shopping	11	4.5	79	12.7	90	10.4
Sitting talking, reading, writing, typing	28	11.6	62	10.0	90	10.4
Cooking	8	3.3	46	7.4	54	6.3
Aerobics	8	3.3	31	5.0	39	4.5
Running/jogging	16	6.6	21	3.4	37	4.3
Reading	5	2.1	30	4.8	35	4.1
Sleeping/napping	8	3.3	21	3.4	29	3.4
Cycling	6	2.5	21	3.4	27	3.1
Weight training	16	6.6	11	1.8	27	3.1
Sexual activity	7	2.9	19	3.1	26	3.0
Standing manual work	12	5.0	14	2.3	26	3.0
Swimming	2	0.8	22	3.5	24	2.8
Exercises - calisthenics	12	5.0	8	1.3	20	2.3
DIY	12	5.0	7	1.1	19	2.2

** gender not reported for 5 participants*
Activities not reported: Baseball, bowling, bowls, farming, ice skating, judo, karate, kick boxing, roller blading, rounders, rugby, skateboarding, skiing, snowboarding, tae kwan do

The most popular physical activity reported overall was walking (most popular for men and second most popular for women) (table 5.10). The most popular activity for women was housework, which was also second most popular for men (however the proportion of women reporting housework was more than double the proportion of men reporting this activity, 53% versus 22%). Clear gender differences are seen between men and women for some activities. As well as housework, a higher proportion of women reported looking after children, shopping, cooking, aerobics, reading and swimming, where as a higher proportion of men reported running/jogging, weight training, standing manual tasks, callisthenics and DIY. The gender differences in the 'sport, games and physical' activities reported are similar to those reported in the General Household Survey, with the exception of swimming where proportions were similar for men and women (Fox and Rickards, 2004).

5.4.3. Diet and physical activity behaviours at baseline and follow-up

The following data must be examined with caution as the numbers recruited and retained do not provide adequate precision of estimation. The results are, therefore, difficult to interpret and may only be used at an exploratory level.

Community Strand

The target behaviour outcomes (fruit and vegetable intake, fat intake and moderate to vigorous physical activity) at each data collection point are displayed in tables 5.11 to 5.14. The primary outcomes (the difference between the intervention and control group in terms of changes in each behaviour from baseline to 12 months) are displayed in table 5.15. There are no significant intervention effects on any of the outcome behaviours at either six and 12 months (table 5.15), although the mean change appears to be approaching significance in the direction of decreasing fat intake at both six and 12 months .

Table 5.11 Diet behaviours at baseline and 6 months in the community strand of the 'Get a Better Life' campaign

		Control (n=28)		Intervention (n=33)	
		Baseline	6 months	Baseline	6 months
% Food energy from fat	*Mean (SD)*	34.4 (8.9)	35.0 (8.1)	32.7 (7.9)	32.2 (8.3)
	Median (range)	34.2 (17.8-52.7)	35.4 (18.8-54.4)	34.9 (17.7-51.7)	32.6 (8.6-46.2)
Fruit and vegetable portions	*Mean (SD)*	3.9 (3.4)	3.2 (2.3)	3.0 (2.1)	3.3 (2.6)
	Median (range)	3.1 (0.0-12.0)	3.0 (0.0-9.6)	3.0 (0.0-7.0)	2.8 (0.0-9.0)

SD = standard deviation

Table 5.12 Diet behaviours at baseline and 12 months in community strand of the 'Get a Better Life' campaign

		Control (n=29)		Intervention (n=34)	
		Baseline	12 months	Baseline	12 months
% Food energy from fat	*Mean (SD)*	34.3 (7.7)	32.1 (7.9)	32.1 (8.9)	29.7 (9.8)
	Median (range)	34.9 (18.2-48.8)	32.7 (9.4-46.8)	34.7 (7.7-49.4)	28.5 (7.9-12.0)
Fruit and vegetable portions	*Mean (SD)*	3.7 (3.3)	3.6 (2.8)	3.2 (2.6)	4.0 (2.8)
	Median (range)	2.5 (0.0-12.0)	2.6 (0.6-13.0)	3.0 (0.0-12.0)	3.6 (0.0-13.0)

SD = standard deviation

Table 5.13 Physical activity behaviours at baseline and 6 months in the community strand of the 'Get a Better Life' campaign

		Control (n=28)		Intervention (n=33)	
		Baseline	6 months	Baseline	6 months
Minutes MVPA	*Mean (SD)*	36 (39)	36 (70)	47 (74)	31 (62)
	Median (range)	30 (0-135)	0 (0-232)	18 (0-330)	0 (0-240)
% ≥30 minutes MVPA		54.5	31.8	43.8	25.0

SD = standard deviation, MVPA = Moderate to vigorous physical activity

Table 5.14 Physical activity behaviours at baseline and 12 months in the community strand of the 'Get a Better Life' campaign

		Control (n=29)		Intervention (n=34)	
		Baseline	12 months	Baseline	12 months
Minutes MVPA	*Mean (SD)*	24 (36)	50 (106)	47 (71)	38 (62)
	Median (range)	0 (0-135)	0 (0-420)	21 (0-330)	15 (0-300)
% ≥30 minutes MVPA		34.5	44.8	44.1	38.2

SD = standard deviation, MVPA = Moderate to vigorous physical activity

Table 5.15 Mean effect of the intervention (intervention minus control) for diet and physical activity behaviours at 6-months and 12-months in the community strand of the 'Get a Better Life' campaign (adjusted for baseline in an ANCOVA model)

	Mean change (bootstrapped 90% CI) 6 months	Mean change (bootstrapped 90% CI) 12 months
% Food energy from fat	-2.6 (-6.2 to 1.0)	-1.6 (-5.1 to 1.7)
Fruit and vegetable portions	0.5 (-0.5 to 1.3)	0.6 (-0.4 to 1.5)
Minutes MVPA	-4 (-37 to 25)	-12 (-50 to 23)

ANCOVA = analysis of covariance, CI = confidence interval, MVPA = Moderate to vigorous physical activity

Internet Strand

The primary outcomes for diet and physical activity behaviours at end data collection point are displayed in tables 5.16 to 5.19. In total, 59 participants provided diet data at both baseline and at 6 months follow-up, and 76 at both baseline and 12 months follow-up. Of these participants, 31 participants reported that the previous day had been a 'normal' day at both baseline and 6 months, and 43 at both baseline and 12 months (tables 5.16 and 5.17). Fifty participants provided physical activity data at baseline and six months, and 61 at baseline and

Table 5.16 Diet behaviours at baseline and 6 months in the internet strand of the 'Get a Better Life' campaign

		Baseline	6 months
All data (n=59)			
% Food energy from fat	*Mean (SD)*	31.9 (11.4)	28.8 (12.9)
	Median (range)	32.9 (4.0-69.1)	32.4 (4.3-49.8)
Fruit and vegetable portions	*Mean (SD)*	2.7 (2.9)	2.6 (2.4)
	Median (range)	2.0 (0.0-12.3)	2.0 (0.0-10.3)
Data reported on a 'normal' day only (n=31)			
% Food energy from fat	*Mean (SD)*	33.3 (12.7)	27.3 (12.4)
	Median (range)	34.9 (4.0-69.1)	29.2 (5.8-49.8)
Fruit and vegetable portions	*Mean (SD)*	2.0 (0.0-10)	2.6 (2.2)
	Median (range)	3.1 (2.9)	2.0 (0.0-7.0)

SD = standard deviation

Table 5.17 Diet behaviours at baseline and 12 months in the internet strand of the 'Get a Better Life' campaign

		Baseline	12 months
All data (n=76)			
% Food energy from fat	*Mean (SD)*	31.1 (9.9)	30.8 (11.3)
	Median (range)	32.4 (4.0-53.8)	29.9 (0.0-56.2)
Fruit and vegetable portions	*Mean (SD)*	3.0 (2.7)	3.1 (2.4)
	Median (range)	2.5 (0-10)	3.0 (0-9.5)
Data reported on a 'normal' day only (n=43)			
% Food energy from fat	*Mean (SD)*	31.6 (10.7)	29.0 (10.3)
	Median (range)	31.5 (4.0-53.8)	29.2 (0.0-49.4)
Fruit and vegetable portions	*Mean (SD)*	3.3 (3.0)	3.4 (2.5)
	Median (range)	3.0 (0-10)	3.0 (0.0-9.5)

SD = standard deviation

12 months. However, data for only 11 participants with baseline and 6 month data, and 13 with baseline and 12 month data, remained once the normal day and over-reporting screening criteria had been applied (tables 5.18 and 5.19). Only data reported on a 'normal' day and screened for over-reporting (physical activity), was used for the difference of the means analysis (table 5.19).

There are no significant changes in any of the primary outcome behaviours between baseline and six months, or baseline and 12 months (table 5.20), although, the mean change appears to be approaching significance in the direction of decreasing fat intake from baseline to six and 12 months.

Table 5.18 Physical activity behaviours at baseline and 6 months in the internet strand of the 'Get a Better' Life campaign

		Baseline	6 months
All data (n=50)			
Minutes MVPA	*Mean (SD)*	66 (175)	829 (1007)
	Median (range)	0 (0-925.)	518 (0-3955)
% ≥30 minutes MVPA		22.0	58.0
Data reported on a 'normal' day only and ≤480 mins MVPA (n=11)			
Minutes MVPA	*Mean (SD)*	75.5 (131.4)	35.5 (117.6)
	Median (range)	0.0 (0.0-325.0)	0.0 (0.0-390.0)

SD = standard deviation, MVPA = Moderate to vigorous physical activity

Table 5.19 Physical activity behaviours at baseline and 12 months in the internet strand of the 'Get a Better Life' campaign

		Baseline	12 months
All data (n=61)			
Minutes MVPA	*Mean (SD)*	67 (153)	656 (914)
	Median (range)	0 (0-630)	105 (0-4150)
% ≥30 minutes MVPA		22.9	55.7
Data reported on a 'normal' day only and ≤480 mins MVPA (n=13)			
Minutes MVPA	*Mean (SD)*	17 (50)	17 (37)
	Median (range)	17 (0-180)	17 (0-105)

SD = standard deviation, MVPA = Moderate to vigorous physical activity

Table 5.20 Difference of means (bootstrapped 90% CI) of the diet and physical activity behaviours at 6-months and 12-months in the internet strand of the 'Get a Better Life' campaign, using data reported on a 'normal day'

	Difference of means (bootstrapped 90% CI) Baseline-6 months	Difference of means (bootstrapped 90% CI) Baseline-12 months
% Food energy from fat	-6.1 (-11.5 to -0.7)	-2.6 (-6.7 to 1.4)
Fruit and vegetable portions	-0.5 (-1.7 to 0.6)	-0.1 (-0.9 to 1.1)
Minutes MVPA	-40.0 (-145.0 to 71.0)	0.4 (-36.5 to 28.1)

CI = confidence interval, MVPA = Moderate to vigorous physical activity

5.4.4. Feedback questionnaires

A total of 45 participants completed the online feedback questionnaire. 61% of the responders stated that they found SNAPA™ easy to use. The general themes of responses to the free text questions "Do you have any comments on the user friendliness of SNAPA™" and "How do you think SNAPA™ could be improved" are reported in table 5.21.

Table 5.21 Usability issues and suggested improvements for SNAPA™ from the 'Get a Better Life' campaign

Theme	No responses
Cumbersome/make simpler	9
Time consuming	6
I.T./access issues	5
Easy to use/no problems	3
Ability to add more items at once/group items	3
More food/activity options	2
Not good for non-computer users	2
Some human contact desired	1
Meal times rather than time periods	1
Clearer instructions how & when to complete	1

5.5. Discussion

From the results of the Get a Better Life campaign the tool appears to be more robust in terms of dietary assessment than physical activity. There was huge variation in the physical activity data, often highly skewed to 0 minutes of moderate to vigorous physical activity but with what appears to be grossly over-reported values in the internet strand. In future studies of this type, the addition of an objective measure such as accelerometry (at least on a sub-sample of the population) could be used to provide more stable physical activity data, with SNAPA™ being use to provide more contextual data. Accelerometry is now a widely used method for the measurement of physical activity, with more and more research groups having access to accelerometer monitors, as well as now being used in national surveys in the England and the US (Craig *et al.*, 2009; Troiano *et al.*, 2008) Exploring how a combination of these two methods could be used poses an interesting question for future research.

No major problems relating to the completion of SNAPA™ occurred during the preliminary method comparison study, when the program was used in a controlled environment. However, when SNAPA™ was used 'live' for the internet strand of the GABL campaign there were obviously some participants who found the program difficult to complete, despite no major problems being reported in the feedback questionnaire. A small number of participants contacted the enquiries email address or hotline, where a member of the team could talk them through the problem. It may be assumed that other people will have had problems with the program, but were less motivated to contact the research team resulting in non-completion of the program and non-recruitment to the campaign; although to what extent, in terms of numbers, will never be known. Although support sessions were arranged at local libraries/public internet access venues where members of the research team were available to assist with any usability issues, these were poorly attended with less than one attendee on average for all sessions. It could be that the actual need for these sessions was low; however, the poor attendance may also be a result of those having usability problems being unable to attend because of time and location (despite putting on a number of sessions, it is highly likely that the sessions were not at the 'right time and place' for those in need). These sessions also did not fit with the spirit of the internet strand of the campaign, that people could take part at their own convenience in terms of time and location. Results from qualitative work with a sub sample of participants who completed this strand of the campaign suggest that the fact that this approach did not involve meeting perceived 'experts' (university staff or health professionals) who may potentially be judgmental (many participants gave losing weight as a reason for taking part, and were disheartened by previous unsuccessful experiences) was one of the main attractions of taking part (Nixon *et al.*, submitted; appendix LL).

In the internet strand of the GABL campaign, the proportion of participants with the highest level of education increased from baseline to follow-up, while the proportion of those with the lowest education level decreased substantially. This finding does correlate with results from the national surveys of internet use (Dutton *et al.*, 2009; Office for National Statistics, 2009) where individuals with the highest level of education were more likely to use the internet. It may be hypothesised that, as those with the highest level of education are more likely to use the internet, they are therefore more likely to continue participation in an internet-based intervention. This pattern was not observed in the community strand of the campaign.

The retention rates the internet strand of the GABL campaign were disappointingly low; however, sustaining engagement in web-based interventions over long periods of time is a challenge that has been identified by others (Anhøj and Jensen, 2004; Eysenbach, 2005; Verheijden *et al.*, 2007). In the study carried out by Verheijden and colleagues, of the 9774 people who participated in the baseline test of a public health web-based health behaviour change program to increase awareness and promote physical activity, 940 (9.6%) used the website more than one (Verheijden *et al.*, 2007). In a small feasibility study of the LinkMedica-Heart internet-based program, no patients (n=25) completed their six month lifestyle change program (Anhøj and Jensen, 2004).

Even in the short-term, dropping out of a web-based study is very easy. As Birnbaum describes "Web participants are free of…social pressure or embarrassment. They simply click a button to quit…and do something else" (Birnbaum, 2004). In a study by O'Neil and Penrod, drop-out rates were monitored over the study carried out over four web-pages (page 1: introduction and general instructions; page 2: consent form with some additional questions; page 3: research materials and questions relating to these; and page 4: demographic questions) (O'Neil and Penrod, 2001). Of 791 participants who accessed the first page, 409 reached the second page, 282 the third page and 193 (22.4% of the beginning sample) completed the study (O'Neil and Penrod, 2001).

Better success in terms of numbers completing a population wide internet-based health promotion campaign was observed in a email-based intervention for pregnant women in the Netherlands, where 16% of participants (1849/11415) opened all email quizes sent to them over the duration of the pregnacy (from week eight to week 40, email sent every four weeks) (Bot *et al.*, 2009). However, this was a specific population group and may not be representative of the general population, and it is unknown if the quizes were completed.

Some workplace internet-based interventions have also shown promising results, with relatively low drop-out rates (Hunter *et al.*, 2008; Plotnikoff *et al.*, 2005; Tate *et al.*, 2001; Ware *et al.*, 2008a). These interventions were carried out over shorter time periods (two programs were 12 weeks and two 6 months) and in relatively controlled conditions where internet access was readily available. These programs were also reasonably structured with regular contact via email (and in some cases in addition to face-to-face and telephone contact) and monitoring of behaviours. GABL was fairly 'light touch' in comparison, with a small amount of email contact (no more than once a month) and monitoring at just the three data collection time-points (baseline, 6 months and 12 months). Participants were free to use the website as often or as little as desired. A more structured, directive intervention may have improved engagement in this strand of the campaign for those who felt isolated by the current method used in this study, however for some; the freedom of the non-directive approach was the aspect they found most appealing (Nixon *et al.*, submitted; appendix LL). Tailored approaches to internet-based interventions may offer a solution for meeting the different, complex needs of individual participants, ensuring the intervention is relevant to them and increasing acceptability (Oenema *et al.*, 2001).

Baseline results suggest that using SNAPA™ as an interviewer administered tool may result in more realistic data, than when it is used as a remote self-completion tool. Outcomes for fat intake were closer to national averages and the extent of over-reporters of physical activity was minimal in the community strand. It is possible that researchers used probing and/or clarification techniques if they thought reports were unrealistic (too low or too high). The other members of the research team received training in completing SNAPA™ by me before administering it to participants. During the training they were not instructed to use probing or clarification techniques, but these may have been used in practice, possibly subconsciously, as a result of the researcher's previous experience of assessment of diet and physical activity. Using two days of recall may have also improved the accuracy of the community strand data as this will have reduced error due to within person variation; however, as a large sample was recruited at baseline for the internet strand within person variation should not have affected the group estimates.

It is also possible that some social desirability bias came into play when SNAPA™ was administered by a researcher as fruit and vegetable intakes reported by the community participants were higher than national averages (although did not reach the five portion target). Again, higher reports of fruit and vegetables may also be a result of interviewer probing. Another note of interest was that sexual activity was not reported when SNAPA™ was administered by a researcher. This may have been because reporting this behaviour may have caused embarrassment or seemed inappropriate. It may also have been that the participant was not aware that this activity was an option as they did not have the time or opportunity to browse the option lists, as the internet participants would have had. There were also a much higher number of participants in the internet strand of the campaign; therefore there was a higher chance that this activity would be reported by somebody.

Unfortunately, because of the low numbers of participants recruited and/or retained in each strand of the GABL campaign, very little can be concluded from the follow-up data collected by SNAPA™. Reasons for the low recruitment and retention are discussed in more detail in forthcoming papers (appendices JJ and KK), although exact reasons are difficult to identify. The usability of SNAPA™ may have played a part in retention issues in the internet strand of the campaign (although it is more likely that this would have affected initial recruitment) but to what extent is unknown.

A major limitation is the unknown ability of SNAPA™ to detect changes in behaviour over time, in response to an intervention; therefore, it is unclear if the observed lack of intervention effect is real or if changes occurred that the assessment method was unable to capture, or a combination of the two. However, this is a common problem in intervention research and, despite the understood importance, the ability of assessment tools used in intervention studies to detect change is rarely reported in the literature. Those studies published are mainly an evaluation of a food frequency questionnaire.

A number of studies have reported long-term reliability, sometimes described as reproducibility, of assessment tools where outcomes from repeat administrations, completed with a substantial period of time between (usually ≥3 months) are correlated (Friis *et al.*, 1997; Katsouyanni *et al.*, 1997; Martínez *et al.*, 1999; Newby *et al.*, 2003; Ocké *et al.*, 1997a; Ocké *et al.*, 1997b; Shu *et al.*, 2004; Smith-Barbaro *et al.*, 1982). In these cases, it is assumed that the diet of the population has remained consistent and is therefore will be similar at each completion. In the study by Martínez et al., in additional to an assessment of long-term reliability, the relative validity of a food frequency questionnaire was also assessed at baseline and at 1-year using a reference method of diet records, providing a further indication of performance of the tool at each time point (Martínez *et al.*, 1999). Segovia-Siapco et al. examined the sensitivity of a food frequency questionnaire at classifying subjects into intervention or control conditions correctly, based on α-linolenic acid intakes, compared with data from diet recalls, and Bland-Altman techniques were used to explore agreement between to measures (Segovia-Siapco *et al.*, 2007). Although these methods provide useful data and give some indication of a tool's performance over a substantial period of time, the question of the ability of the tool to detect change in response to an intervention is not fully addressed.

The concept of responsiveness was originally described by Guyatt et al. and is used to evaluate an instrument's sensitivity to change (Guyatt *et al.*, 1987). This concept has since been adapted for use in nutrition-intervention research where it is defined as the "observed intervention effect divided by its standard deviation", where the observed intervention effect is calculated as the mean change (of outcome of interest) in the intervention arm minus the mean change in the control arm (Kristal *et al.*, 1994). The use of responsiveness for the evaluation of a small number of food frequency questionnaires and a short questionnaire on fat-related diet habits compared with dietary recalls have been reported (Kristal *et al.*, 1994; Thomson *et al.*, 2003). Although there are limitations involved in this method and comparisons are difficult because of the lack of literature addressing sensitivity of assessment tools, it is advised that responsiveness, along with relative validity and reliability, of assessment tools used is reported in future intervention studies (Kristal *et al.*, 1994). This, in turn, will help to address to latter problem.

5.6. Conclusion

The GABL campaign demonstrates how SNAPA™ can be used in a 'live', free-living, population wide research project in different settings and requirements. Findings from this study identified a number of issues involved in using SNAPA™ in this way that would need to be considered if used in future studies of this kind.

However, this study also identified a number of potential applications for SNAPA™ that could be explored in future evaluation work.

Chapter Six: Primary method comparison

6.1. Introduction

The primary, in-depth validation of the Synchronised Nutrition and Activity Program for Adults (SNAPA™) was carried out between March and October 2009. In this study, concurrent validity of SNAPA™ was assessed against reference methods considered more accurate then those used in the preliminary method comparison study. This secondary study was also carried out over longer time period with multiple days of data collection, in order to investigate the ability of SNAPA™ to assess habitual behaviour.

6.2. Aims and Objectives

The aims of the study were to:

- Evaluate the validity and reliability of SNAPA™ against the reference methods (combined heart rate and accelerometry; accelerometry alone; and diet observation) at a group level
- Explore the prevalence of the sample meeting current population physical activity recommendations using accurate and precise objective measures.

The objectives of the study were to:

- Accurately and precisely measure physical activity variables in adults using the new combined heart rate and accelerometer (Actiheart®);
- Objectively measure physical activity variables in adults using a conventional hip mounted accelerometer (Actigraph™);
- Accurately observe and record dietary intake during work/college/university lunchtimes;
- Measure physical activity variables and dietary intake in adults using SNAPA™ (minutes of moderate to vigorous physical activity, energy intake, fat intake [grams and percentage of food energy] and fruit and vegetable intake);

- Compare the estimated physical activity variables (minutes of moderate to vigorous physical activity and vigorous physical activity) from the Actigraph™ monitor against the new combined Actiheart® monitor.

6.3. Methods

6.3.1. Ethical approval

This study was approved by the Teesside University, School of Health and Social Care Research Ethics Committee and by the Durham University School of Medicine and Health Research Ethics Committee after my PhD was transferred to Durham University in May 2009 (appendices Z and AA).

6.3.2. Recruitment of participants

Workplaces and colleges in the Tees Valley were approached by contacting the relevant workplace/student health representatives; team leaders and/or heads of department (appendix BB). Invitations to take part in the study were sent to staff/students via the relevant workplace/student representative, along with a participant information sheet explaining the study (appendix CC). Anyone interested in taking part in the study was asked to contact the research team (by telephone, email or letter), so that they could ask any questions and arrange a pre-study meeting with the researcher. During the pre-study meeting, any further questions were answered, pre-participation screening was carried out and consent was obtained (appendix DD).

6.3.3. Study Protocol

On the first day of the study (day one), participants were fitted with an Actiheart® and Actigraph™ monitor and had anthropometric measurements taken. Participants were instructed to wear the monitors for seven full days (days two to eight): the Actiheart® at all times (including time spent sleeping, bathing/showering and swimming), and the Actigraph™ during waking hours (removed for any water-based activities, and high-contact activities if required). Between days three and nine, participants were asked to complete the online assessment tool (SNAPA™) on each of the five working days (Mon-Fri). On four of the working days (between days two to eight), participants had their dietary intake observed during their

Figure 6.1 Two example study timetables for the primary method comparison study

	Day								
	1 Mon	2 Tue	3 Wed	4 Thur	5 Fri	6 Sat	7 Sun	8 Mon	9 Tue
Actiheart® and Actigraph™	S	✓	✓	✓	✓	✓	✓	✓	R
Lunchtime observation		✓	✓	✓				✓	
SNAPA™			✓	✓	✓			✓	✓
Anthropometric measurements	✓								
Step test									✓

S = set-up, R = returned

	Day								
	1 Wed	2 Thur	3 Fri	4 Sat	5 Sun	6 Mon	7 Tue	8 Wed	9 Tue
Actiheart® and Actigraph™	S	✓	✓	✓	✓	✓	✓	✓	R
Lunchtime observation		✓				✓	✓	✓	
SNAPA™			✓			✓	✓	✓	✓
Anthropometric measurements	✓								
Step test									✓

S = set-up, R = returned

lunchtime break. After the seven full days of wearing the monitors, participants were asked to meet with the researcher to complete a step test and hand in their Actiheart® and Actigraph™ monitors. Figure 6.1 shows two examples of a typical study period with the monitors being set-up on a Monday or a Wednesday. Most participants began the study on a Monday; some started later in the week to allow for bank holidays and/or other commitments.

Distribution and collection of physical activity monitors

The Actiheart® and Actigraph™ monitors were given to each participant during the set-up session on first day of the study. A demonstration of how the monitors were to be worn was given by the researcher, along with written instructions (appendix EE), and participants had the opportunity to ask questions. Electrodes were positioned on the participant and the Actiheart® was fitted during the set-up session. A signal test was carried out to ensure that the Actiheart® monitor was recording the participant's heart rate cleanly, before the monitor was set to record for the study period. Participants were instructed to start wearing the Actigraph™ monitor the following day. Participants were asked to wear the Actiheart® monitor at all times (including during water-based activities) and the Actigraph™ monitor during waking hours (removing for any water-based activities). A diary sheet was also provided (appendix EE) on which the participants were instructed to record any times when the Actigraph™ monitor was not worn. If, for some reason, the participant needed to remove the Actiheart® monitor, they were asked to also record this on the diary sheet. Both monitors and the diary sheet were handed back to the researcher on the final day (day nine) of the study when the step test was carried out.

6.3.5. SNAPA™

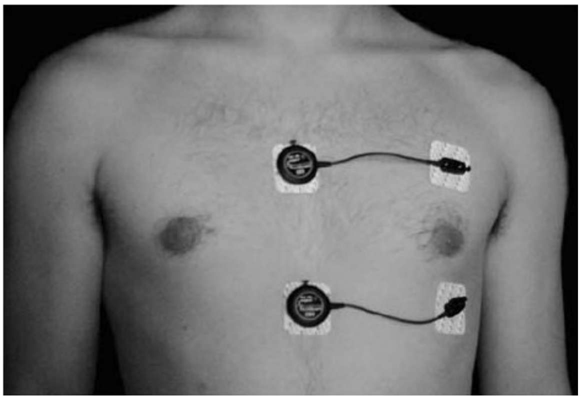
The development, format and completion process of SNAPA™ has been described in previous chapters of this thesis. The web-link that was used to access SNAPA™ was sent to each participant via email. The web-link for each participant was unique and incorporated their ID number so that the data are automatically linked to this number (the participant was not required to enter their number at any stage). A personalised email containing the web-link was sent to the participant on the morning of the first day on which they were required to complete the program. An email containing a reminder to complete the program, along with their unique web-link, was sent on the morning of each subsequent day on which they were required to complete the program.

6.3.6. Combined heart rate and accelerometry

The method of combining heart rate measurements with accelerometry is described fully in chapter one. The monitor used in this study was the Actiheart® (CamNtech, Cambridge, UK). The Actiheart® is small (main component is 32mm in diameter and 6mm in depth, with a wire of approximately 100mm length running to a smaller unit [5x11x22mm]), lightweight (10 grams), fully waterproof monitor and has a battery life of 21 days.

The Actiheart® monitor is attached to two electrocardiogram electrodes, placed either at the upper (at the level of the third intercostal space) or lower (just below the apex of the sternum chest) position (both positions shown in figure 6.2). In this study the position of the monitor was determined by participant preference and in most cases the lower chest position was used. There was little concern that the position of the monitor would affect the data collected. A previous study showed that although cleaner heart rate data are achieved in the lower position, there is no significant difference in energy expenditure or count variables produced by monitors positioned at each site (Brage *et al.*, 2006).

Figure 6.2 Actiheart® placement sites



Prior to the application of the Actiheart® electrodes, the participant's skin was prepared. Skin preparation is essential to obtaining robust heart rate data from electrocardiogram electrodes. The skin preparation involved cleaning the skin and then, through gentle abrasion, the removal of the layer of dead skin (the stratum corneum). The most effective and practical method is very gentle abrasion using the purpose-made Cardio prep pads (Unomedical, Redditch, UK), which results in minimal skin damage or irritation. A few gentle strokes decreases impedance substantially with little or no skin reddening.

Individual calibration

In order to calibrate the data collected by the Actiheart® monitor to the individual, each participant was asked to carry out the calibration step test. The step test is a submaximal test, which starts at a rate of 15 steps per minute (an intensity of four METs; moderate intensity) and builds to a rate of 33 steps per minute (eight METs; vigorous intensity) over eight minutes. American College of Sports Medicine and American Heart Association pre-participation screening guidelines were used to exclude individuals for whom carrying out exercise at this intensity may be harmful and require medical supervision (American College of Sports Medicine, 2006) (see appendix FF for pre-participation screening questionnaire). Participants were instructed to wear suitable footwear when carrying out the step test.

6.3.7. Accelerometry

The accelerometer monitor used for this study reference was the updated version of the Actigraph™ GT1M used in the primary method comparison study: the Actigraph™ GT3X (Actigraph™, Pensacola, FL, USA). As the GT1M model, the Actigraph™ GT3X is a small, lightweight motion sensor monitor that captures and stores instances of movement, expressed as counts per epoch. In addition, the Actigraph™ GT3X is a triaxial monitor and captures movement in the horizontal anterior-posterior and mediolateral planes, as well as vertical movement. However, at the time of this study, cut points for these additional axes for this monitor were not established for conversion into intensity values, therefore only count data measured in the vertical axis were used in the analysis, using established cut points (Troiano *et al.*, 2008). The Actigraph™ GT3X also collects step data. Participants were instructed to wear the accelerometer on their right hip, under or over their clothes (whichever they preferred).

6.3.8. Diet observation

Direct diet observation was used as the reference method for dietary assessment in an attempt to overcome any limitations of comparing a self-reported method with another self-reported method. Although direct diet observation is also a subjective method, it is carried out prospectively by trained observers, eliminating memory and subject associated biases; and is considered a suitable reference method for the validation of self-reported methods (Mertz, 1992). Direct diet observation took place during lunchtime periods in the participant's workplace, college or university, and was carried out by trained researchers. Following a protocol based on that carried out by Domel Baxter and colleagues (Domel Baxter *et al.,* 2002), researchers recorded food and drink items brought to the eating area, along with estimated portion sizes for each food/drink item (using a photographic atlas of food portion sizes (Nelson *et al.*, 1997), and recorded how much of each food/drink item was consumed as 'all', 'most' (approximately ¾ of portion), 'half', 'some' (approximately ¼ of portion) or 'none' (appendices GG and HH). Food/drink items recorded were coded, and the portion size of the food/drink item consumed converted into grams, before the data were inputted into the WISP dietary software (version 3.0; Tinuviel Software, Anglesey, UK).

6.3.9. Anthropometrics

Height, weight and waist circumference measurements were taken by a Level 1 International Society for the Advancement of Kinanthropometry accredited researcher (me). Height was measured using a free-standing stadiometer to ±0.1cm (Leicester Height Measure, Harlow Printing Ltd, Tyne and Wear, UK) and weight measured using an electronic digital scale to ±0.1kg (Tanita 800S Personal Scales, Chasmors Ltd, London). The equipment was placed on a flat surface, and participants were asked to remove their shoes and any heavy clothing (coats, jumpers etc) for accuracy of measurements. Waist circumference was measured using a non-stretch, spring weighted anthropometric tape in the horizontal plane, midway between the inferior margin of the ribs and the superior border of the iliac crest to ±0.1cm.

6.3.10. Feedback

Individual feedback on the participant's anthropometric measures, diet intake and physical activity levels was provided, on request, electronically via email within approximately two weeks of the participant completing the study. An email was also sent to each participant (incorporated in the email containing their individual feedback if requested) asking them to complete an electronic feedback questionnaire (created using the free online survey and questionnaire tool: surveymonkey.com) with questions asking opinions on each data collection method and the study as a whole (appendix II).

6.3.11. Incentive

All participants who completed the study received high street shopping vouchers to the value of £30.

6.3.12. Data analysis

Diet and physical activity variables

Data from SNAPA™ was downloaded from the MySQL database and exported into Microsoft Access (2007) database software to extract diet and physical activity outcomes.

The Actiheart data were downloaded and processed using the Actiheart software (version 4.0.11; CamNtech, Cambridge, UK) that applies a branched equation model to calculate energy expenditure and MET values, using differentially weighted activity and heart rate data (Brage *et al.*, 2004), for each minute of the measurement period. Data were exported as comma-separated values (CSV) files into software developed by Teesside University for further processing and estimation of total minutes of moderate to vigorous physical activity and vigorous physical activity per day, measured in bouts of one minute or more and 10 minutes or more.

The Actigraph™ data were downloaded using the ActiLife software (version 4.4.1; Actigraph™, Pensacola, FL, USA) to obtain activity counts for each minute of data collected. These data were exported as CSV files into software developed by Teesside University for further processing. Each minute was assigned an intensity value using the adult specific cut-points for counts per minute calculated for use in NHANES 2003-2004 (Troiano *et al.*, 2008): a threshold criteria of 2020 counts for moderate activity was calculated as equivalent to three METs, and 5999 counts for vigorous activity as equivalent to six METs. The intensity values assigned were used to estimate the total number of minutes of moderate to vigorous physical activity and vigorous physical activity per day, measured in bouts of ≥1 minute and ≥10 minutes. Any days on which the Actigraph™ and/or Actiheart® monitors were not worn (as recorded by the participant on the diary sheet) were removed from the analysis. For the Actigraph™, a minimum wear time of 10 hours (identified using the inclinometer data) was also applied.

Diet observation data were coded and entered in a Microsoft Excel (2007) worksheet for food item agreement analysis, and the dietary software WISP (version 3.0; Tinuviel Software, Anglesey, UK) for nutritional analysis. Only food items reported in SNAPA™ under the meal classification 'lunch' and/or reported at the time of the dietary observation (±1 hour) were included in the method comparison analysis. For the food item agreement analysis, a method adapted from the methods used by two observation studies in children (Baranowski *et al.*, 2002; Warren *et al.*, 2003) was applied. Food items were classified as 'observed' if any of the food was eaten, i.e. would only not be classified as observed if the food item was coded as 'none' eaten by the observer. Each food item observed and/or reported in SNAPA™ was classified as a 'match', 'omission' or 'phantom' (termed 'intrusion' in U.S. literature). A food item was classified as a 'match' if the food item observed was reported in SNAPA™ (or a food item within the same food category, if an exact match was not available in SNAPA™, for example 'malt loaf' observed, reported as 'bread' in SNAPA™); an 'omission' if the food item observed was not reported in SNAPA™; or a 'phantom' if a food item was reported in SNAPA™, but not observed. Match and phantom rates for each day were calculated using the following formulas:

Match rate = (Number of 'match' food items/number of food items observed) ×100

Phantom rate = (Number of 'phantom' food items/number of food items observed) ×100

Anthropometric data were inputted into a Microsoft Access (2007) database under the appropriate user ID. Basic descriptive statistical analysis was carried out using SPSS (version 15.0, SSPS inc, Chicago, US) for all outcomes.

Method comparison analysis

For the method comparison analysis, data collected by SNAPA™ were compared with data collected by each reference method separately, i.e. SNAPA™ and accelerometry; SNAPA™ and synchronised heart rate and accelerometry; SNAPA™ and diet observation. Data collected by synchronised heart rate and accelerometry were also compared with data collected by accelerometry alone. Only days where data had been collected by both the methods being compared were included in the analysis.

Preliminary analysis revealed no substantial differences in measurement error between males and females; therefore all analyses were carried out on a pooled sample. Individual mean values per day for each outcome variable were calculated, and used to calculate group means. The difference between the group means of each comparison method was then determined. Linear regression analysis was carried out to determine the correlation co-efficient, and Passing-Bablok (type II) regression to evaluate bias (Passing and Bablok, 1983) using the Analyse IT® software (Analyse IT® Software Ltd, Leeds, UK). Fixed bias is indicated by substantial departure from a zero intercept, with a slope substantially different from one revealing proportional bias. In brief Passing-Bablok (type II) regression determines the agreement with the line of identity (perfect agreement). Ordinary least-squares (Type 1) linear regression cannot be used to compare the obtained line of best fit with the line of identity, as the method assumes that the error is only in the Y variable and that X is measured without error. The Passing-Bablok method allows for imprecision in both methods. Importantly, with respect to the current study, this imprecision need not be normally distributed, it can have nonconstant variance over the sampling range, and the Passing-Bablok regression line is not biased strongly by outliers. In this study the bootstrapping re-sampling method did not need to be applied to the data collected (as had in the preliminary method comparison), as the collection of more than one day of data resulted in more uniform distributions.

As a secondary analysis, Bland-Altman plots were used to explore the precision of SNAPA™ at an individual level (Bland & Altman, 1999).

Prevalence data analysis

For the investigation of each method of measuring habitual dietary and physical activity levels, prevalence data that could be compared with national survey data were determined. For the prevalence data analysis all valid days of data collected by each method were included, with the exception of the dietary observation. As dietary observation only collects data for one meal of the day, these data were unable to give any representation of diet for the whole day and cannot be used for estimation of habitual intake. Basic descriptive statistics were carried out to calculate group means of each outcome variable for each method, and where appropriate, prevalence of the sample meeting current government recommendations.

6.4. Results

6.4.1. Demographics

A total of 78 participants were recruited to the study. Of these, only one participant dropped out of the study (female, aged 47 years). The characteristics of the participants who completed the study (n = 77) are displayed in table 6.1. In this study, data were not collected on occupation as, due to the nature of the recruitment, it was known that the participants were either employed (full or part-time) or in education (full or part-time). Descriptions of the types of organisations which participated, and the numbers recruited from each organisation are detailed in table 6.2.

Table 6.1 Sample characteristics of participants in the primary method comparison study (n=77)

	Frequency (%)	**Mean (SD)**
Age (years)		34.4 (11.1)
Gender		
Male	30 (39.0%)	
Female	47 (61.0%)	
Anthropometrics		
BMI (kg/m^2)		25.1 (4.5)
Waist circumference (cm)		79.9 (12.5)
BMI categories (kg/m^2)		
<18.50	3 (3.9)	
18.50-24.99	43 (55.8)	
25.00-29.99	20 (26.0)	
≥30.00	10 (13.0)	

Table 6.2 Descriptions of participating organisations in the primary method comparison study

Description of organisation	**Description of job roles**	**Number of participants**
University	Office-based, teaching, research (field and laboratory) or PhD students	20 (staff) 4 (students)
Further Education College (1)	Students from sports-based course	17 (students only)
Further Education College (2)	Office-based and student support	15 (staff only)
Industrial company	Office-based and manual	8
Garden centre	Office-based and manual	7
Data processing company	Office-based	5
Council	Office and community-based	1

6.4.2. Compliance with methods

Six participants did not complete SNAPA™. Two of these could not complete the program as SNAPA™ was not compatible with an updated version of the Internet Explorer web-browser (version 8) (they did not have convenient access to older version) that was launched in March 2009. The first participant who experienced this issue did so in September 2009.

Table 6.3 Number of participants (%) and number of days data provided from each assessment method (n=77)

	No days								Total
	0	1	2	3	4	5	6	7	completed
SNAPA™	6 (7.8)	3 (3.9)	7 (9.1)	9 (11.7)	18 (23.4)	23 (29.9)	5 (6.5)	6 (7.8)	71 (92.2)
Diet observation	22 (28.6)	6 (7.8)	14 (18.2)	22 (28.6)	13 (16.9)	-	-	-	55 (71.4)
Actiheart®	7 (9.1)	0 (0.0)	0 (0.0)	2 (2.6)	1 (1.3)	0 (0.0)	2 (2.6)	65 (84.4)	70 (90.9)
Actigraph™	2 (2.6)	1 (1.3)	1 (1.3)	1 (1.3)	2 (2.6)	9 (11.7)	14 (18.2)	47 (61.0)	75 (97.4)

SNAPA™ = Synchronised Nutrition and Activity Program for Adults

For the remaining participants, compliance with SNAPA™ was good, with the highest percentage of participants completing SNAPA™ on the five days requested. Commonly, a minimum of three days data is often collected when measuring day-by-day physical activity and diet behaviour, although more days are desirable, especially when using self-reported methods that have more noise than objective methods. In this study 79% of participants provided at least three days of data using SNAPA™. It is also interesting to see that 11 participants (14%) completed SNAPA™ on more days than requested.

The lowest, although not unexpected, compliance was with the direct dietary observation method. Diet observation data was collected for just over 70% of all of the participants, with only 17% being observed on all of the four days requested. Of those who were observed, the highest percentage of participants were observed at three lunchtimes (29%).

Although more participants provided data from the Actigraph™ monitor than the Actiheart® monitor (97% vs. 91%), a much greater number of participants wore the Actiheart® monitor for all of the seven days requested, than wore the Actigraph™ for seven days (84% vs. 61%). Again, this result is not unexpected as the Actiheart® monitor is worn by the participant at all times; most of the missing days for the Actiheart® monitor were due to participants forgetting to replace the monitor in the morning after their night's sleep. Monitor reliability did not appear to be an issue in this study, with data being lost for only two participants (one Actiheart® and one Actigraph™) as a result of faults with the monitors. Unfortunately, two sets of data (one Actiheart® and one Actigraph™ – different participants) were lost due to researcher error when either setting up the monitor (Actigraph™) or downloading the data (Actiheart®). Two participants removed their Actiheart® monitors for one day due to attending a spa day. The remaining incomplete sets of data from the Actiheart® monitors (n=10) were caused by the participants having some degree of reaction to the electrodes. The percentage of participants who provided Actiheart® and Actigraph™ data for at least three days were 91% and 73%, respectively.

Due to the differing levels of compliance for each method, the amount of data which could be used for the method comparison analysis varied for each behaviour and method. Table 6.4 shows the number of participants who provided suitable data for comparison (where data had been collected for the same day for both methods being compared) and the mean number of days that could be compared.

Table 6.4 Number of participants providing data for each method comparison analysis and the mean number of days where data collected by both methods

Methods for comparison	**N**	**Mean number of days**
SNAPA™, Diet observation	46	2.7
SNAPA™, Actiheart®	64	4.2
SNAPA™, Actigraph™	66	4.0
Actiheart™, Actigraph™	68	6.2

SNAPA™ = Synchronised Nutrition and Activity Program for Adults

6.4.3. Method comparison

Diet Observation verses SNAPA™

Diet data from both SNAPA™ and direct diet observation were collected for 46 participants, resulting in data for a total of 97 eating occasions. Participants were asked to be observed for four days, however, as discussed previously, this was not always possible and some days were missed. The mean number of days where SNAPA™ and observation data were both collected for each participant, was 2.7 days. The days labelled in table 6.5 are numbered in time order, i.e. day one represents the first day of observation of the study group and the day four, the final day. Therefore participants may not necessarily have data for sequential days, for example, if they were unable to attend the first and third observation days; they will only have data for days two and four. The data are reported this way in an attempt to account for any recall bias as it may be assumed that participants may be able to recall using SNAPA™ as they become more familiar with the program (participants were still instructed to complete SNAPA™ even if they were unable to attend any lunchtime observations although this did not always happen).

SNAPA™ appeared to show good agreement with direct dietary observation at a food item agreement level, with high match rates and low phantom rates (table 6.5). Of the 97 eating occasions observed, 102 food items from a total of 467 food items were not recalled in SNAPA™ (forgotten foods). The most commonly forgotten food item was fruit (24%), followed by yogurt (14%), vegetables (13%), bread (7%), chocolate, biscuits and desserts (7%), crisps (5%), rice and potatoes (5%), soup (4%), meat and fish (4%), extras/sides (e.g. coleslaw, gravy) (4%), tea and coffee (3%), soft drinks (including fizzy drinks) (3%), complete meals (e.g. chilli con carne, cottage pie) (3%), sandwiches (2%) and cheese (1%).

Table 6.5 Food item agreement between SNAPA™ and direct dietary observation (n=46)

Day	Match rate (%)	Phantom rate (%)
1	74.9	4.1
2	80.3	1.6
3	84.8	8.0
4	86.8	8.6
Mean	**81.7**	**5.6**

SNAPA™ = Synchronised Nutrition and Activity Program for Adults

A total of 17 ‘phantom’ foods were recalled in SNAPA™, and of these the most common phantom foods were chocolate, sweets and biscuits (35%), followed by tea and coffee (29%). The following food items were reported as a phantom food once each (6% of total): sandwich, crisps, fruit, vegetable, milk and chicken/turkey.

Table 6.6 Agreement between SNAPA™ and direct dietary observation at a nutritional level (n=46)

	SNAPA™		Diet Observation			
	Mean	**(SD)**	**Mean**	**(SD)**	**Difference of means**	**(90% CI)**
Energy intake (MJ)	2.0	(0.9)	1.7	(0.6)	0.2	(0.03, 0.4)
Fat intake (g)	19.7	(12.3)	13.4	(7.2)	6.3	(3.4, 9.2)
Percentage food energy from fat	34.6	(14.2)	29.5	(11.0)	5.1	(1.7, 8.5)
Portions FV	0.9	(0.8)	0.9	(0.7)	0.0	(-0.2, 0.3)

SNAPA™ = Synchronised Nutrition and Activity Program for Adults, FV = fruit and vegetable

Group means for the dietary variables for lunchtime intake as estimated by SNAPA™ and dietary observation are displayed in table 6.6. From these results, SNAPA™ appears to over estimate intakes in terms of energy and fat, compared with dietary observation. There were no differences between the methods in terms of fruit and vegetable intake.

Linear regression analysis revealed a correlations of 0.55 (90% CI, 0.35 to 0.70), with a standard error of the estimate (SEE) of 0.52 MJ (90% CI: 0.46, 0.63); 0.39 (90% CI, 0.16 to 0.58), SEE of 6.7g (90% CI, 5.7 to 8.1); 0.42 (90% CI, 0.19 to 0.60), SEE of 10.0% (90% CI, 8.5 to 12.0); and 0.56 (90% CI, 0.36 to 0.71), SEE = 0.65 portions, (90% CI, 0.56 to 0.79), between SNAPA™ and direct diet observation estimations of energy intake; fat intake (g); percentage of food energy from fat and fruit and vegetable intake respectively.

The Passing-Bablok (type II) variables are displayed in table 6.7 and can be used in the following equation:

$$\text{SNAPA™} = x\,(\text{Observation}) + y$$

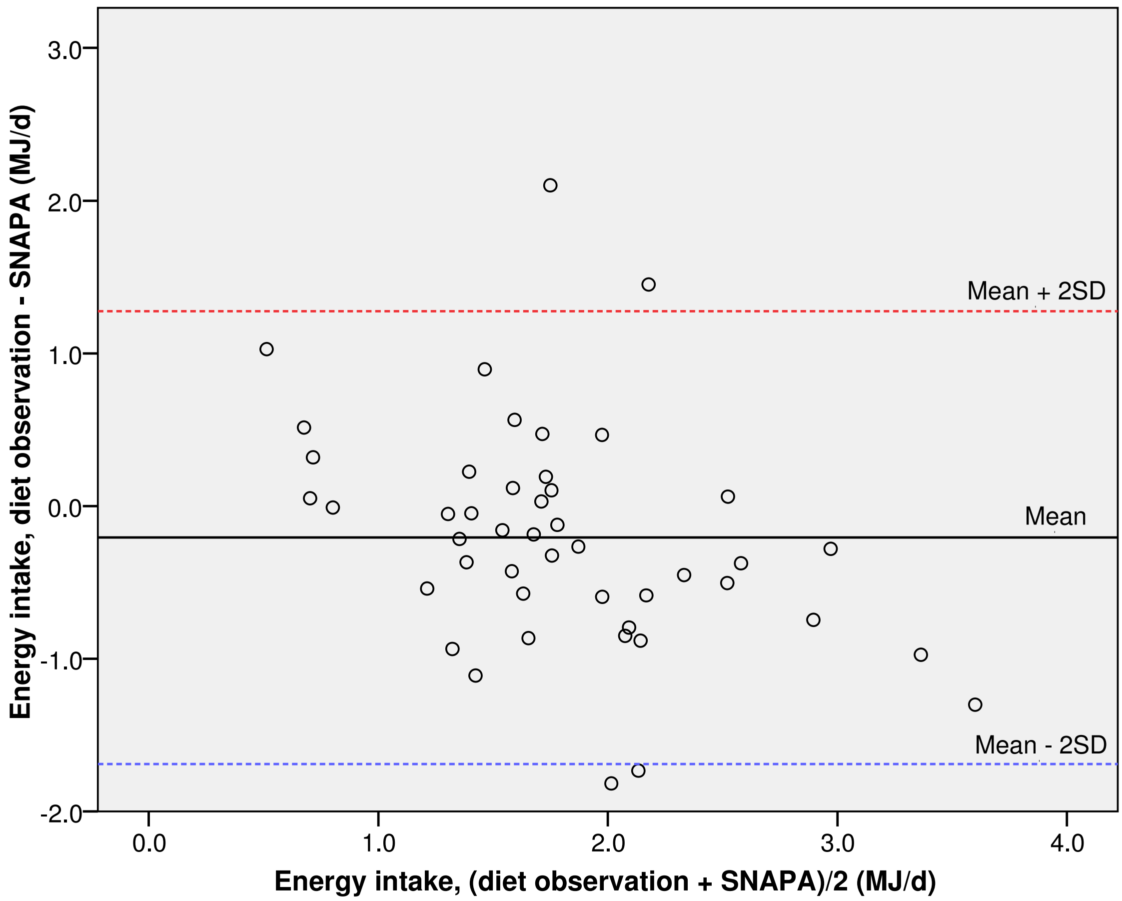
Passing-Bablok (type II) regression analysis revealed both fixed and proportional bias for the estimation of energy intake; no marked fixed bias but substantial proportional bias for fat intake in grams; and no substantial biases for percentage of food energy from fat or number of portions of fruits and vegetables (where there was almost perfect agreement).

Table 6.7 Passing-Bablok regression variables, SNAPA™ vs. direct dietary observation at a nutritional level (n=46)

	Slope (x)	**(90% CI)**	**Intercept (y)**	**(90% CI)**
Energy intake (MJ)	1.53	(1.23, 1.89)	-0.64	(-1.25, -0.17)
Fat intake (g)	1.98	(1.42, 2.66)	-5.9	(-14.2, 0.6)
Percentage food energy from fat	1.35	(0.98, 2.03)	-3.9	(-22.9, 6.3)
Portions FV	1.0	(0,86, 1.25)	0	(-0.1, 0.1)

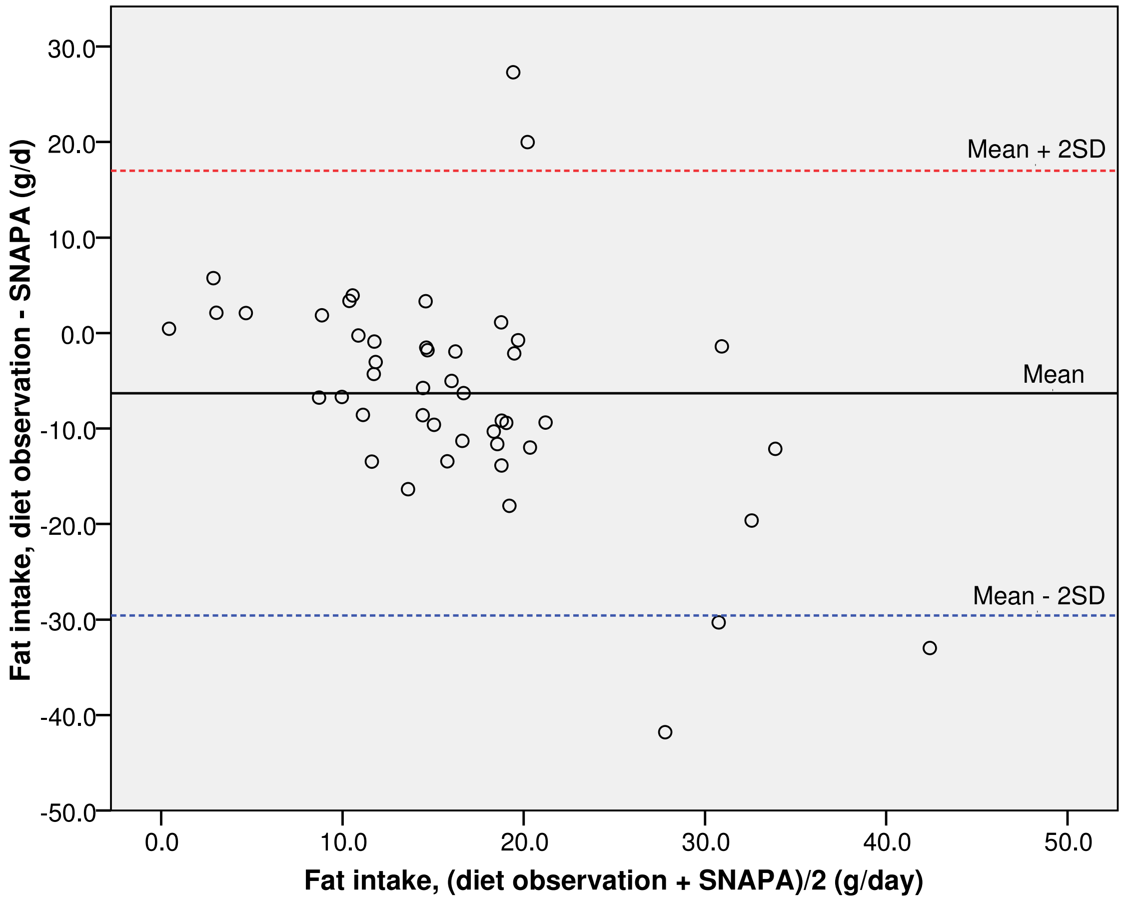
SNAPA™ = Synchronised Nutrition and Activity Program for Adults, FV = fruit and vegetable, CI = confidence intervals

Figure 6.3 Bland-Altman plot of the mean difference between diet observation and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined lunchtime energy intake versus the mean of the two measurements (n=46)



Agreement between SNAPA™ and dietary observation at an individual level for each diet variable using the Bland-Altman method are displayed in figures 6.3 to 6.6. As also reported in table 6.6, the mean bias indicates that SNAPA™ overestimates energy intake in comparison to energy intake observed by 0.2MJ (figure 6.3). At an individual level, 95% of participants could lie between a underestimation of 1.3MJ and a overestimation of 1.7MJ.

Figure 6.4 Bland-Altman plot of the mean difference between diet observation and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined lunchtime fat intake in grams versus the mean of the two measurements (n=46)



In terms of fat intake, SNAPA™ overestimated lunchtime intakes by 6.3 grams (table 6.6 and figure 6.4) and by 5.1% of food energy from fat (table 6.6 and figure 6.5) compared with observed intakes. Limits of agreement for fat intake variables appear to be broad, and 95% of participants could lie between an overestimation 30 grams of fat or 33% of food energy from fat, and an underestimation of 17 grams of fat or 23% of food energy from fat. For grams of fat, agreement between the methods appears to be lower at higher mean intakes.

Figure 6.5 Bland-Altman plot of the mean difference between diet observation and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined lunchtime percentage of food energy from fat versus the mean of the two measurements (n=46)

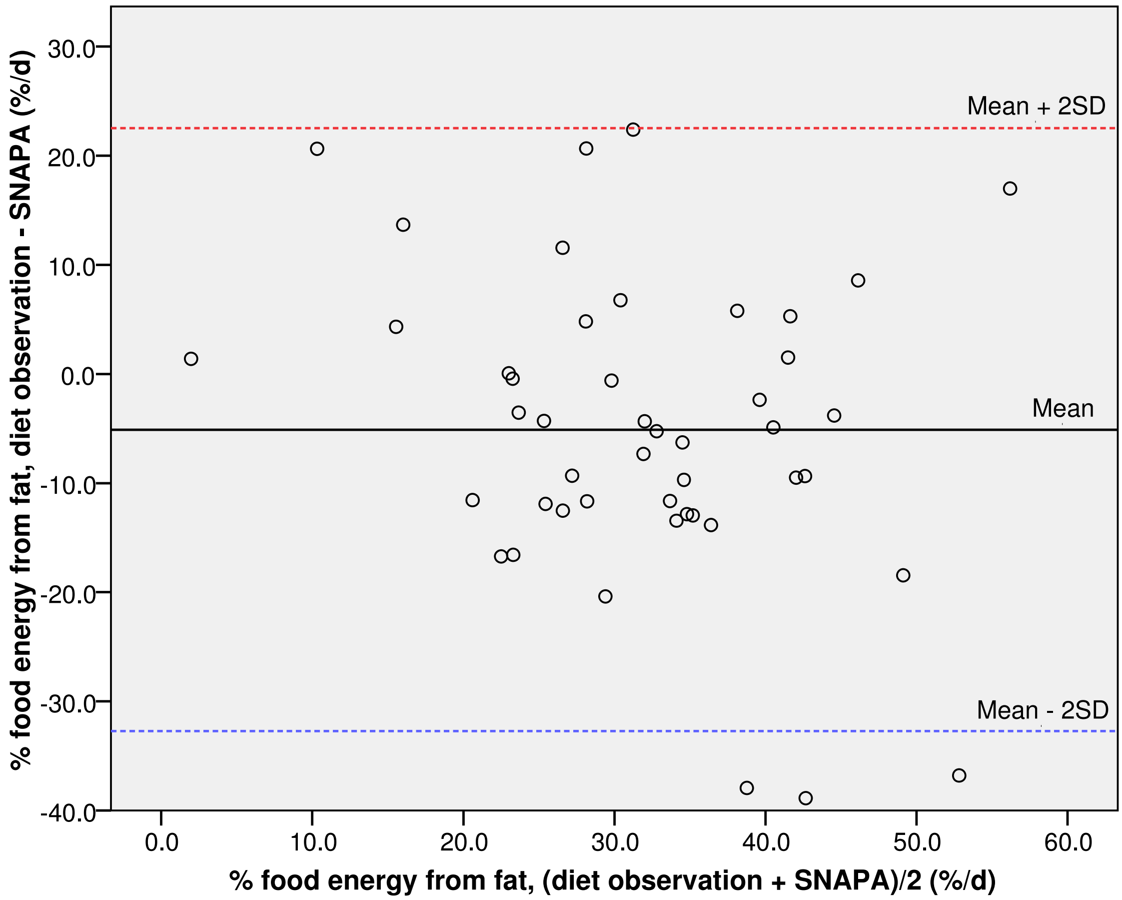
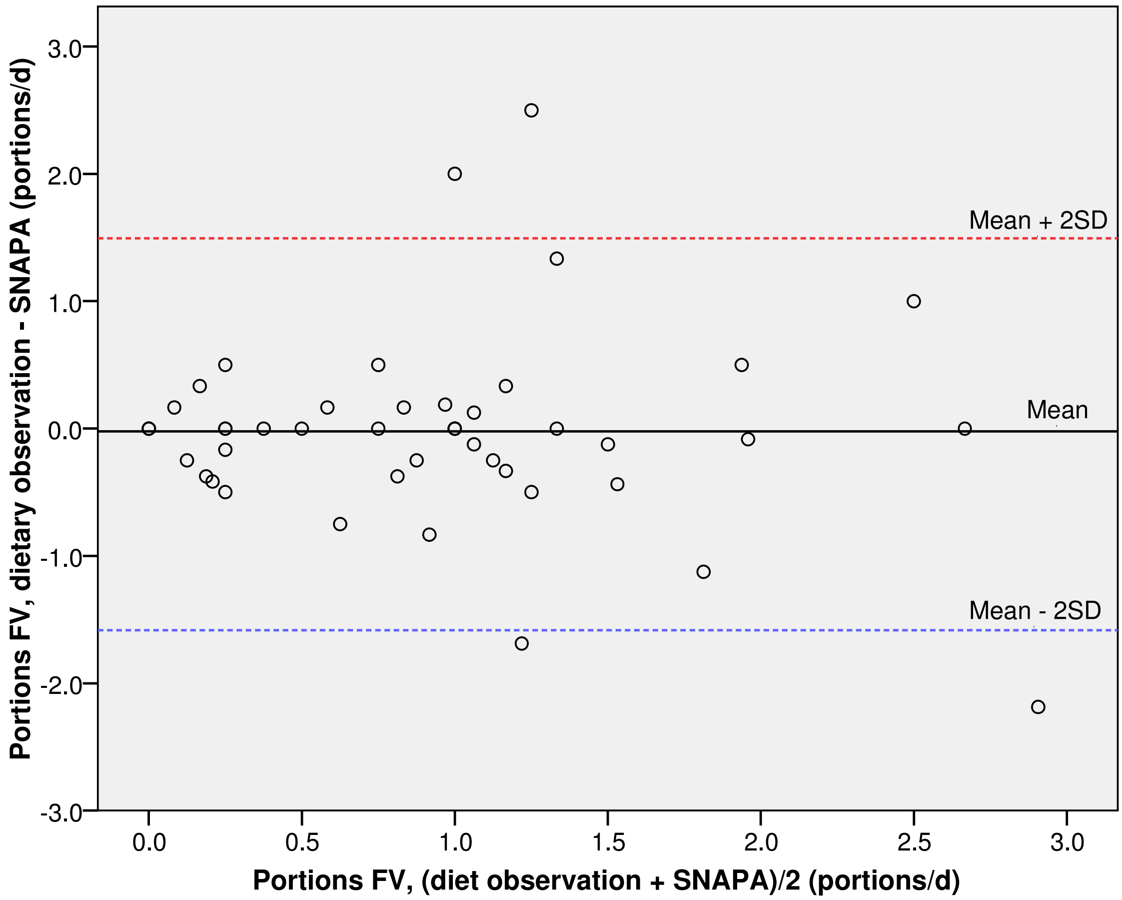


Figure 6.6 Bland-Altman plot of the mean difference between diet observation and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined lunchtime portions of fruits and vegetables versus the mean of the two measurements (n=46)



For lunchtime fruit and vegetable intake the mean bias between SNAPA™ and observation was almost zero (table 6.6 and figure 6.6) and limits of agreement were relatively narrow at ±1.5 portions.

<u>Food substitutions</u>

A number of food items that were observed during lunchtimes, were not included in the food option list in SNAPA™ therefore an alternative food item was reported (table 6.8). Although these substitutions may have accounted for some of the between method differences in terms of nutrient values, most of the substituted food items matched the observed food item in terms of food group, or had similar properties (for example jelly is categorised in the high sugar and/or high fats group of chocolate, biscuits, sweets etc, whereas the substituted food item, jam, is categorised in the high sugar spreads).

The following foods were also identified as missing from SNAPA™ through feedback from participants: rice pudding, cheesecake, coleslaw, cous cous, malt loaf, pork, fajitas, chicken with sauce, pesto, rice cakes, pickle and vegetable burgers.

Table 6.8 Food item substitutions reported in SNAPA™ for foods observed

Food item observed	Food group(s)	Food item reported	Food group(s)
Chinese chicken wrap	Meat Bread (Savoury sauces, ketchup, gravy)	Chicken, mayonnaise, pitta	Meat Bread Fats
Chinese chicken wrap	Meat Bread (Savoury sauces, ketchup, gravy)	Sandwich, white bread, meat filling	Meat Bread
Crab sticks	Fish (not takeaway) and seafood	White fish	Fish (not takeaway) and seafood
Crème fraiche	Dairy	Cream	Dairy
Hot cross bun	Chocolate, biscuits, sweets, cakes, ice cream, custard	Cake	Chocolate, biscuits, sweets, cakes, ice cream, custard
Jelly*	Chocolate, biscuits, sweets, cakes, ice cream, custard	Jam	High sugar spreads
Lemon mousse	Chocolate, biscuits, sweets, cakes, ice cream, custard	Yogurt	Dairy
Malt loaf	Bread	Bread	Bread
Muffin	Chocolate, biscuits, sweets, cakes, ice cream, custard	Cake	Chocolate, biscuits, sweets, cakes, ice cream, custard
Oatcakes	Chocolate, biscuits, sweets, cakes, ice cream, custard	Biscuits	Chocolate, biscuits, sweets, cakes, ice cream, custard
Tortilla	Bread	Pitta	Bread

**Jelly was reported as jam on 3 occasions*
SNAPA™ = Synchronised Nutrition and Activity Program for Adults

Actiheart® versus SNAPA™

When comparing SNAPA™ with Actiheart®, data for one participant (male) was removed as preliminary analysis revealed the participant's data as a high leverage (influence) point. Group means of minutes of moderate to vigorous physical activity indicate that SNAPA™ under-reports moderate to vigorous activity, when compared with all minutes measured by the Actiheart®; but over-reports when compared with minutes of moderate to vigorous physical activity measured by the Actiheart® that were carried out in bouts of ten minutes or more (table 6.9).

Table 6.9 Agreement between SNAPA™ and combined heart rate and accelerometry (Actiheart®) (n=63)

	SNAPA™*		Actiheart®			
	Mean	**(SD)**	**Mean**	**(SD)**	**Difference of means**	**(90% CI)**
Minutes of $MVPA_{ALL}$	56	(98)	99	(55)	-43	(-54, -30)
Minutes of $MVPA_{10+}$	56	(98)	34	(32)	22	(10, 33)

**10 minute bout criteria only applied to Actiheart® data*
SNAPA = Synchronised Nutrition and Activity Program for Adults
MVPA = moderate to vigorous physical activity
$MVPA_{ALL}$= all activity at 3 or more METs (metabolic equivalents)
$MVPA_{10+}$= activity at 3 or more METs in bouts of 10 minutes or more

Linear regression correlations between minutes of moderate to vigorous physical activity estimated using SNAPA™ and minutes of moderate to vigorous physical activity measured by the Actiheart® monitor were 0.44 (90% CI, 0.25 to 0.59), SEE of 50 minutes (90% CI, 44 to 59) when including all minutes measured by the Actiheart®; and 0.27 (90% CI, 0.06 to 0.49), SEE of 31 minutes (90% CI, 27 to 36) when only minutes included in bouts of or above ten minutes measured by the Actiheart® were included.

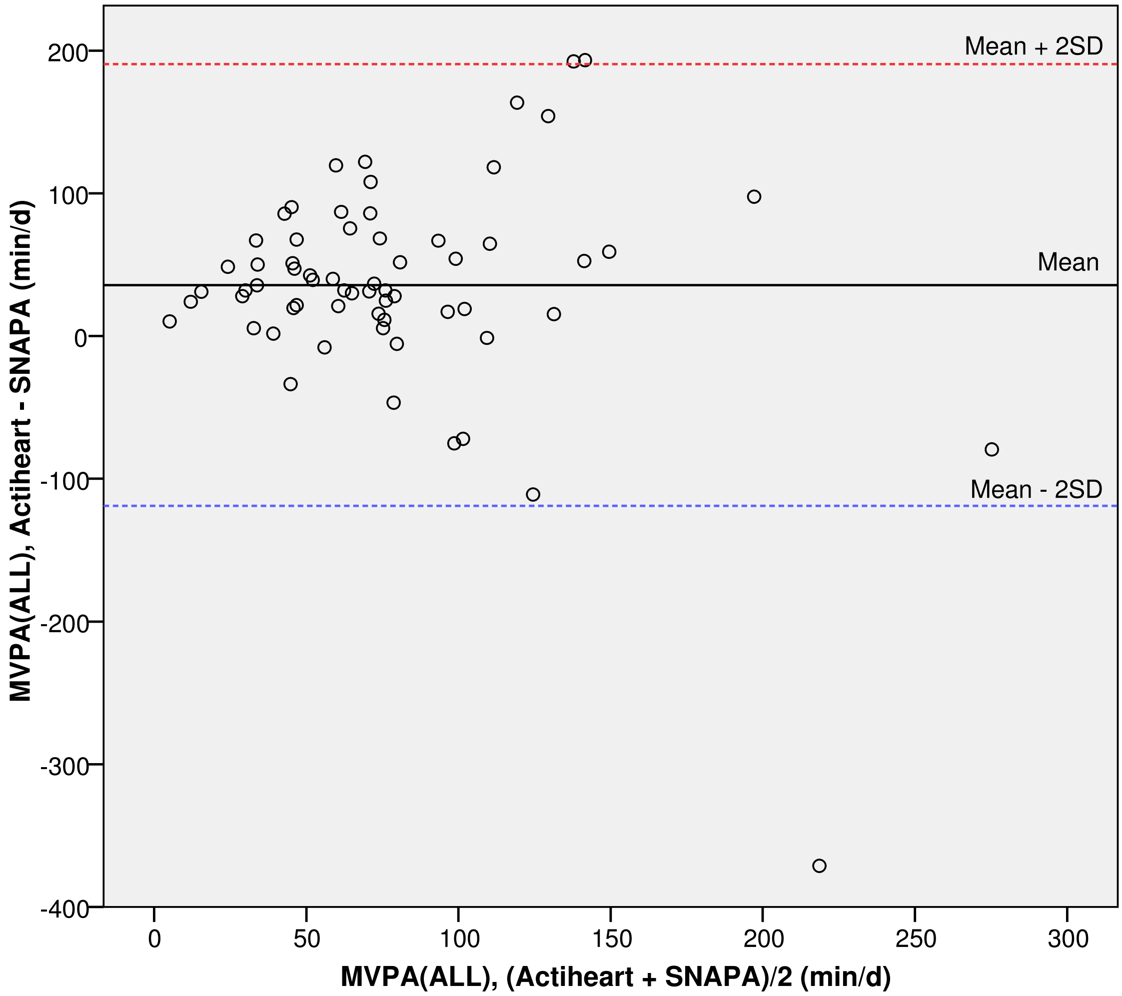
Passing-Bablok regression analysis revealed a fixed bias, but no substantial proportional bias, when all minutes of moderate to vigorous physical activity measured by Actiheart® were included. When only minutes carried out in bouts of 10 minutes or more measured by the Actiheart® were included, a substantial proportional bias, but no fixed bias was revealed (table 6.10).

Table 6.10 Passing-Bablok regression variables, SNAPA™ vs. combined heart rate and accelerometry (Actiheart®) (n=63)

	Slope (x)	**(90% CI)**	**Intercept (y)**	**(90% CI)**
Minutes of $MVPA_{ALL}$	0.9	(0.67, 1.23)	-28	(-53, -14)
Minutes of $MVPA_{10+}$	1.47	(1.17, 2.16)	0	(-13, 8)

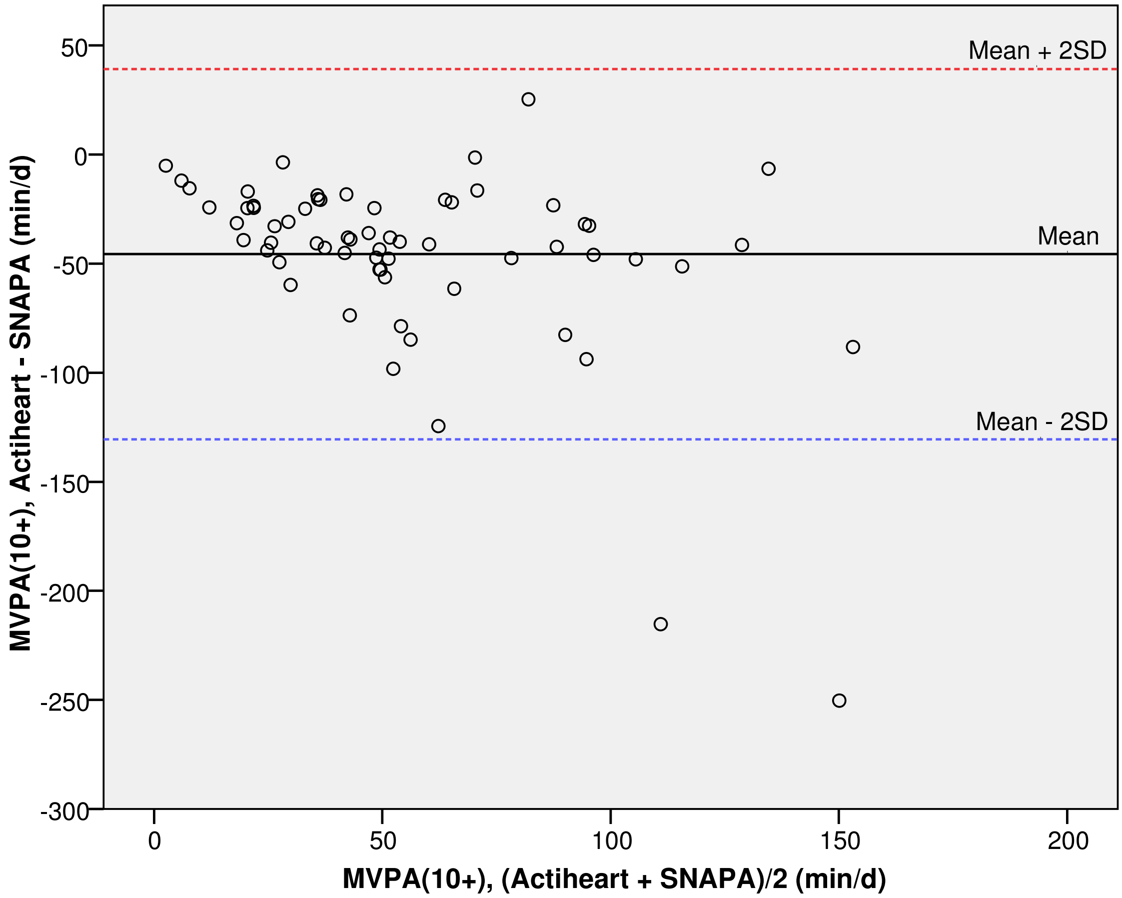
SNAPA™ = Synchronised Nutrition and Activity Program for Adults,
MVPA = moderate to vigorous physical activity,CI = confidence intervals
$MVPA_{ALL}$= all activity at 3 or more METs (metabolic equivalents)
$MVPA_{10+}$= activity at 3 or more METs in bouts of 10 minutes or more

Figure 6.7 Bland-Altman plot of the mean difference between combined heart rate and accelerometry (Actiheart®) and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined moderate to vigorous physical activity (all minutes) versus the mean of the two measurements (n=64)



Individual level agreement, for the whole sample, between SNAPA™ and combined heart rate and accelerometry using the Bland-Altman method are displayed in figures 6.7 and 6.8. In the comparison of minutes of moderate to vigorous physical activity reported in SNAPA™ with all minutes of moderate to vigorous physical activity determined by combined heart rate and accelerometry, as reported in table 6.9, there was an overall mean bias of SNAPA™ underestimating by 35 minutes. The limits of agreement ranged from 191 to -119 minutes, where a negative value indicates overestimation by SNAPA™; however these will have been skewed by one large outlier where minutes of moderate to vigorous physical activity was hugely overestimated using SNAPA™.

Figure 6.8 Bland-Altman plot of the mean difference between combined heart rate and accelerometry (Actiheart®) and the Synchronised Nutrition and Activity Program for Adults (SNAPA™) determined moderate to vigorous physical activity (in bouts of 10 minutes or more) versus the mean of the two measurements (n=64)



In the comparison of minutes of moderate to vigorous physical activity reported in SNAPA™ with minutes of moderate to vigorous physical activity determined by combined heart rate and accelerometry that were carried out in bouts of at least 10 minutes, as reported in table 6.9, there was an overall mean bias of SNAPA™ overestimating by 46 minutes. The width of the limits of agreement was smaller in this comparison than the previous one, and ranged from 39 to -131 minutes, where a negative value indicates overestimation by SNAPA™. There appears to be two outliers, overestimating moderate to vigorous physical activity.

Actigraph™ versus SNAPA™

The group mean of minutes of moderate to vigorous physical activity was significantly higher when estimated by SNAPA™, compared with those as measured by the Actigraph™ monitor, for all minutes of moderate to vigorous physical activity and when the ten minute bout criteria was applied (table 6.11).

Table 6.11 Agreement between SNAPA™ and accelerometry (Actigraph™ GT3X) (n=66)

	SNAPA™*		**Actigraph™ GT3X**			
	Mean	**(SD)**	**Mean**	**(SD)**	**Difference of means**	**(90% CI)**
Minutes of $MVPA_{ALL}$	57.3	(68.3)	36.4	(25.3)	24	(9, 38)
Minutes of $MVPA_{10+}$	57.3	(68.3)	12.49	(18.2)	47	(32, 62)

**10 minute bout criteria only applied to Actigraph™ data*
SNAPA = Synchronised Nutrition and Activity Program for Adults
MVPA = moderate to vigorous physical activity
$MVPA_{ALL}$= all activity at 3 or more METs (metabolic equivalents)
$MVPA_{10+}$= activity at 3 or more METs in bouts of 10 minutes or more

Linear regression analysis revealed non significant correlations of 0.12 (90% CI, -0.09 to 0.32), SEE of 19 minutes (90% CI, 17 to 22) and 0.10 (90% CI, -0.10, 0.30), SEE of 13 minutes (90% CI, 11 to 15), between minutes of moderate to vigorous physical activity estimated by SNAPA™ and measured by the Actigraph™ monitor including all minutes of moderate to vigorous activity, and those included in bouts of ten minutes or more, respectively. Non-linear relationships between the methods were detected in Passing-Bablok for both conditions; therefore this data is not presented. Possible reasons for the lack of agreement between these methods are discussed later in this chapter.

Actiheart® vs Actigraph™

Comparing the group means as measured by both monitors, the outcomes calculated using data from the Actigraph™ were significantly lower than those calculated using Actiheart® data for both minutes of moderate to vigorous physical activity (all and 10+ minute bout criteria) and all minutes of vigorous physical activity alone (table 6.12).

Table 6.12 Agreement between accelerometry (Actigraph™ GT3X) and combined heart rate and accelerometry (Actiheart®) (n=68)

	Actigraph™ GT3X		Actiheart®			
	Mean	**(SD)**	**Mean**	**(SD)**	**Difference of means**	**(90% CI)**
Minutes of $MVPA_{ALL}$	34.8	(24.3)	97.6	(62.7)	-63	(-75, -51)
Minutes of $MVPA_{10+}$	10.9	(15.4)	34.8	(34.6)	-24	(-30, -18)
Minutes of VPA	3.0	(5.4)	11.8	(14.0)	-9	(-11, -6)

MVPA = moderate to vigorous physical activity, VPA = vigorous physical activity
$MVPA_{ALL}$= all activity at 3 or more METs (metabolic equivalents)
$MVPA_{10+}$= activity at 3 or more METs in bouts of 10 minutes or more

When comparing all minutes of moderate to vigorous physical activity measured by both monitors, the correlation between the methods was relatively low (0.27 [90% CI, 0.07 to 0.45], SEE = 61 minutes [90% CI, 53 to 71]). However, when only minutes of moderate to vigorous physical activity carried out in bouts of ten minutes or more were included in the analysis, a correlation of 0.52 (90% CI, 0.36 to 0.65), SEE of 30 minutes (90% CI, 26 to 35), was achieved.

Passing-Bablok regression analysis revealed significant proportional biases, but no substantial fixed biases, for both sets of data (table 6.13). A further comparison of these methods, and possible reasons for the disparities, is discussed in the next section of this chapter.

Table 6.13 Passing-Bablok regression variables, accelerometry (Actigraph™ GT3X) vs. combined heart rate and accelerometry (Actiheart®) (n=68)

	Slope (x)	**(90% CI)**	**Intercept (y)**	**(90% CI)**
Minutes of $MVPA_{ALL}$	0.32	(0.19, 0.49)	5	(-7, 12)
Minutes of $MVPA_{10+}$	0.28	(0.19, 0.40)	0	(-0.9, 1.3)

MVPA = moderate to vigorous physical activity,CI = confidence intervals
$MVPA_{ALL}$= all activity at 3 or more METs (metabolic equivalents)
$MVPA_{10+}$= activity at 3 or more METs in bouts of 10 minutes or more

6.4.4. Overall dietary intake and physical activity levels

Dietary intake

The dietary outcomes as estimated using SNAPA™ are displayed in table 6.14. The value for energy intake falls between the mean values reported in the National Diet and Nutrition Survey (NDNS) of 9.72 MJ for men and 6.87 MJ for women (Henderson *et al.*, 2003), although it is closer to the mean value for women. This may be due to a higher proportion of women than men in this study (61% versus 39%). However, with the proportion of men to women in this sample, the energy intake value may be considered lower than expected, indicating some degree of misreporting or error. The estimated mean daily intake of fat in grams from SNAPA™ also falls between the means reported in the NDNS (86.5g for men, 61.4g for women) (Henderson *et al.*, 2003), but again may be considered lower then expected. The resulting group mean daily percentage of food energy from fat estimated by SNAPA™ is lower than national means for both men and women (35.8% and 34.9% respectively) (Henderson *et al.*, 2003).

Table 6.14 Overall dietary outcomes estimated by SNAPA™

	Mean	**(SD)**
All participants (n=71)		
Energy intake (MJ)	7.2	(2.3)
Fat intake (g)	66.3	(25.5)
Percentage food energy from fat	33.8	(6.8)
Portions fruit and vegetable	2.4	(1.6)
Excluding number of days <3 (n=61)		
Energy intake (MJ)	7.4	(2.2)
Fat intake (g)	68.4	(25.2)
Percentage food energy from fat	34.0	(6.0)
Portions fruit and vegetable	2.6	(1.6)

SNAPA™ = Synchronised Nutrition and Activity Program for Adults,
SD = standard deviation

The group mean for number of portions of fruit and vegetables per day estimated by SNAPA™ was marginally lower than those reported in the NDNS (2.7 portions for men, 2.8 portions for women) (Henderson *et al.*, 2002). Including only participants with three days or more of SNAPA™ data in the analysis resulted in slight increases in the mean of each outcome variable. Overall, average intakes estimated by SNAPA™ for the group meet the recommended target of no more than 35% of daily food energy intake from fat (Department of Health, 1991); but do not meet the '5 a day' target for fruit and vegetable intake.

To explore the issue of underreporting further, secondary analysis was run comparing energy intake estimated using SNAPA™ against energy expenditure estimated by combined heart rate and accelerometry (table 6.15). Estimated energy intake was lower than estimated energy expenditure for the whole sample. Although numbers were small and unsuitable for reliable sub-group analysis, the differences were explored in men and women separately. The results showed larger differences between estimated energy intake and energy expenditure in men compared with women. These data suggest that underreporting had occurred overall, but was greater in men. These data must be interpreted with some caution as it was unknown if the sample were in energy balance, and combined heart rate and accelerometry is not an established method of measuring total energy expenditure. Larger samples are required to explore gender differences, and possibly other subgroups such as overweight and obesity, when reporting energy intake using SNAPA™.

Table 6.15 Energy intake estimated using SNAPA™ vs. total energy expenditure estimated using combined heart rate and accelerometry (Actiheart®), participants ≥3 days SNAPA™ data

	Energy intake (MJ)		**Energy expenditure (MJ)**			
	Mean	**(SD)**	**Mean**	**(SD)**	**Difference of means**	**(90% CI)**
All participants (n=53)	7.3	2.3	11.2	2.7	-4.0	(-4.7, -3.2)
Men (n=23)	7.3	2.0	13.4	2.6	-6.1	(-7.1, -5.0)
Women (n=30)	7.2	2.5	9.6	1.4	-2.4	(-3.1, -1.6)

SNAPA™ = Synchronised Nutrition and Activity Program for Adults, SD = standard deviation, CI = confidence interval

Physical activity prevalence and comparison with recommendations

Table 6.16 shows the group means for each physical activity outcome variable for each method and the prevalence of those meeting the Department of Health recommendation of achieving 30 minutes or more of moderate intensity activity on at least five days of the week (Department of Health, 2004). Group means for minutes of moderate to vigorous physical activity (measured per minute and in accumulated bouts of 10 minutes or more) and vigorous physical activity were higher using synchronised heart rate and accelerometry, compared with accelerometry alone.

Table 6.16 Overall physical activity outcomes estimated by combined heart rate and accelerometry (Actiheart®), accelerometry (Actigraph™) and SNAPA™

	Actiheart (n=70)		**Actigraph™ (n=75)**		**SNAPA (n=71)**	
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**
Number of days recorded	6.8	(0.8)	6.3	(1.2)	4.3	(1.5)
Minutes $MVPA_{ALL}$ per day	97.3	(25.1)	34.7	(59.7)	61.9	(67.1)
Minutes $MVPA_{10+}$ per day	35.3	(33.2)	10.8	(5.0)	-	-
Minutes VPA per day	11.8	(14.0)	2.9	(5.3)	-	-
	n	**(%)**	**n**	**(%)**	**n**	**(%)**
% achieving '5 a week' recommendation	14	(20.0)	1	(1.3)	-	-
% ≥30 minutes MVPA per day	29	(41.4)	7	(9.3)	50	(70.4)

SNAPA™ = Synchronised Nutrition and Activity Program for Adults, SD = standard deviation, MVPA = moderate to vigorous physical activity, VPA = vigorous physical activity
$MVPA_{ALL}$= all activity at 3 or more METs (metabolic equivalents)
$MVPA_{10+}$= activity at 3 or more METs in bouts of 10 minutes or more

There are currently few published studies that report free-living activity of populations as measured by combined heart rate and accelerometry; however in comparison to those that have (although caution is required due to differences in study populations), the values reported in this study do not appear to be unrealistic. In a UK study in a sample of 90 men (aged 45-64), values (mean ±SD) for minutes of moderate to vigorous physical activity per day were 124 ±49 (all minutes) and 42 ±26 (minutes accumulated in bouts of 10 minutes or more); and for vigorous physical activity, 8 ±11 minutes per day (Thompson *et al.*, 2009). In a study of 33 adults living in Cameroon total minutes of moderate to vigorous physical activity were 133 ±58 (Assah *et al.*, 2010).

Only one participant (1.4%) achieved the recommended level of physical activity based on the accelerometry data. Via synchronised heart rate and accelerometry, however, the sample point prevalence was 20% (31.0% in men, n=9 and 12.2% in women, n=5). The mean minutes of moderate to vigorous physical activity per day as estimated by SNAPA™ fell between the values determined by combined heart rate and accelerometry, and by accelerometry alone when all minutes of moderate to vigorous physical activity were considered. However, when only minutes carried in bouts of 10 minutes or more as measured by the physical activity monitors were used, the values from both monitors were lower then the SNAPA™ estimation.

The data collected using SNAPA™ could not be used to estimate the prevalence of participants meeting the 'at least five times a week' recommendation as only four days of completion were required for the purpose of this study. It may be assumed that for activity reports of less than a week, if a participant reported an average daily moderate to vigorous physical activity of 30 minutes or more, that they are considered active. The percentage of participants achieving on average 30 minutes or more moderate to vigorous physical activity over on the days reported using SNAPA™, however, were much higher than the percentage as measured by both monitors. Again this is mostly likely due to the difference in recording periods and this criteria is discussed further on in this section.

There were only three instances when total minutes of moderate to vigorous physical activity reported was greater than 480 minutes (two were same participant). These days were removed from the analysis.

<u>Prevalence of non-ambulatory, water-based and lifestyle activities</u>

A possible reason for the between-method difference of combined heart rate and accelerometry and accelerometry alone, and the lack of agreement between SNAPA™ and accelerometry alone, is that both combined heart rate and accelerometry and SNAPA™ collect data on non-ambulatory (including weight bearing) activities and water-based activities, that are not well captured, or not captured at all, by accelerometry alone (see chapter one).

Table 6.17 Overall prevalence of non-ambulatory, water-based and lifestyle activities report in SNAPA™ (n=71)

Activity	n	%	Mean daily minutes (reporters)	Mean daily minutes (all participants)
Cycling	13	16.9	35	6
Weight training	24	31.2	74	25
Standing manual work	3	3.9	71	3
Household activities*	45	58.4	97	61
Swimming	8	10.4	49	6
Water sports	3	3.9	87	4

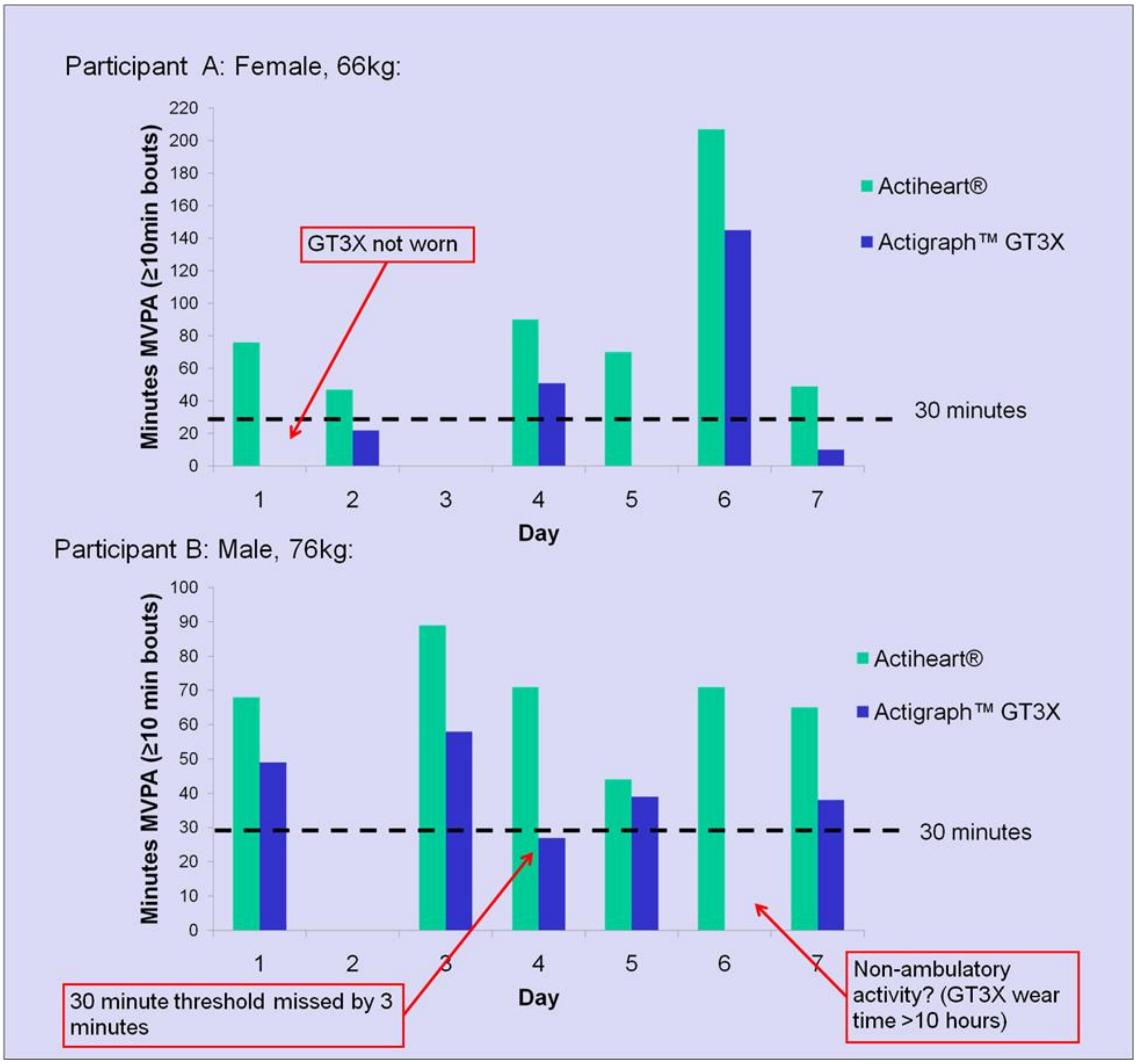
**housework, household tasks, gardening, DIY*
SNAPA™ = Synchronised Nutrition and Activity Program for Adults

Table 6.17 displays the number of participants (from the total sample providing SNAPA™ data, n=71) who reported these types of activities when completing SNAPA™ in this current study. Weight training was the most popular of the activities (31% of the total sample). For those who reported weight training, they carried out a mean of 74 minutes per day. When averaged over the total sample that completed SNAPA™, weight lifting contributes approximately 25 minutes per day to the total number of minutes of activity reported per day. Cycling, standing manual work and swimming contribute approximately 6, 3 and 6 minutes respectively. Three participants in this sample reported taking part in water sports, which was most likely rowing (anecdotal evidence from researcher notes). As the accelerometer was removed during water-based activities, this data would not have been captured (and if rowing was carried out it is unlikely to have been captured anyway due to its non-ambulatory nature). However, overall water sports contributed only 4 minutes to the group mean of activity per day.

Another weakness of accelerometry alone is its inability to capture lifestyle activities with complex movement patterns (static and dynamic) such as household chores and occupational activity (Matthews, 2005; Welk *et al.*, 2000b). Over half of the sample reported some type of household activity (housework, household chores, gardening and DIY) and these activities contributed approximately 61 minutes overall to the total time spent in activity per day. The contribution from occupational activities can not be determined as there is no way of identifying this data from all data collected by SNAPA™. Although, the majority of household activities may have been of less than moderate intensity (less than three METs), there may have been some that may have reached the moderate threshold. For example cleaning (moderate and vigorous effort), vacuuming, mopping, moving furniture, painting, sanding, digging, planting and mowing lawn (not using a sit-on mower) all have MET values greater or equal to three (Ainsworth *et al.*, 2000). It is worth noting, however, that these types of activities are also very hard to quantify (in terms of time and intensity) by self-report, as they are often unstructured and indistinct and therefore more difficult to recall from memory (Baranowski, 1988; Matthews, 2005). Therefore, there will be large errors from both SNAPA™ and accelerometry alone in the measurement of these behaviours. However, these types of activities are measured with relative accurately by combined heart rate and accelerometry (Crouter *et al.*, 2007; Luke *et al.*, 1997; Strath *et al.*, 2001; Strath *et al.*, 2002; Thompson *et al.*, 2006) which will explain some of the differences between the outcomes estimated using data collected by the Actigraph™ and Actiheart® monitors. Finally, there may be a small contribution to the between method differences due to the removal of the accelerometer monitor when taking part in high contact sports such as competitive football. However, looking at data from the participant's diary sheets, there were very few instances where this occurred.

Individual examples of total minutes of moderate to vigorous physical activity recorded each day by the Actigraph™ and Actiheart® monitors are displayed in figure 6.3 and further demonstrate the differences between the monitors. The limitation of Actigraph™ non-wear time is highlighted by participant A, where one day, on which 30 minutes may have been achieved, could not be counted as the minimum wear time criteria was not reached. Using the self-reported data collected by SNAPA™, it is known that activities reported by participant B included cycling and weight training (although unfortunately SNAPA™ was not completed for days four or six where the main differences are seen), which may account for some of the differences between the methods. However, participant A's only self-reported moderate to vigorous physical activity was walking which does not explain the differences between the monitors for this participant. Therefore, the between method differences may be mainly a result of some activities reaching the moderate intensity cut-point criteria for synchronised heart rate and accelerometry, but not for accelerometry alone.

Figure 6.9 Individual examples of moderate to vigorous physical activity (MVPA) measured each day by combined heart rate and accelerometry (Actiheart®) and accelerometry alone (Actigraph™ GT3X)



Step count data

The number of steps achieved by each participant each day was collected using the step count function on the Actigraph™ monitor. Only steps recorded when accelerometry counts reached 500cpm were included, as steps recording at lower counts were unlikely to be a result of a full step (Tudor-Locke *et al.*, 2009). The group mean for steps per day are presented in table 6.18, along with the proportion of participants meeting each activity classifications determined by average daily step count (Tudor-Locke *et al.*, 2008).

Table 6.18 Step data measured using the Actigraph™ GT3X monitor (n=75)

	Frequency (%)	**Mean (SD)**
Number of steps		6289 (3121)
Activity categories		
Sedentary (<5000 steps per day)	25 (33.3)	
Low active (5000–7499 steps per day)	30 (40.0)	
Somewhat active (7500–9999 steps per day)	12 (16.0)	
Active (10,000–12,499 steps per day)	4 (5.3)	
Highly active (≥12,500 steps per day)	4 (5.3)	

SD = standard deviation

Summary of prevalence data

Table 6.19 displays the participants who provided data from both physical activity monitors and completed SNAPA™ on at least 3 days and met the Department of Health recommendation or were categorised as 'active' by average daily minutes of moderate to vigorous physical activity or step counts. The results demonstrate the complexity of applying prevalence criteria to physical activity data and that prevalence can vary dramatically depending on the method and criteria applied. In this sample, 39 participants reported achieving a mean of 30 or more minutes of moderate to vigorous physical activity using SNAPA™. Compared with the Actiheart® data, 22 of these participants reported correctly, but only 10 also met the recommendation. Six participants reported less than 30 minutes moderate to vigorous physical activity per day using SNAPA™, however they did achieve this using the Actiheart® data (three of whom also met recommendation).

The one participant who met the 'at least five a week' recommendation, and therefore a daily mean of 30 or more minutes of moderate to vigorous physical activity, using data from both monitors, failed to report a mean of 30 or more minutes of moderate to vigorous physical activity using SNAPA™.

Table 6.19 Examples of prevalence at an individual level of those meeting the 'at least five times a week' recommendation or an 'active' criteria*

	At least 5 a week		≥30 MVPA per day			
	AH	AG	AH	AG	SNAPA™	≥10000 steps
1	✓	✓	✓	✓	×	✓
2	✓	×	✓	✓	✓	✓
3	✓	×	✓	✓	✓	✓
4	✓	×	✓	✓	✓	✓
5	✓	×	✓	×	✓	×
6	✓	×	✓	×	✓	×
7	✓	×	✓	×	✓	×
8	✓	×	✓	×	✓	×
9	✓	×	✓	×	✓	×
10	✓	×	✓	×	✓	×
11	✓	×	✓	×	✓	×
12	✓	×	✓	✓	×	×
13	✓	×	✓	×	×	×
14	×	×	✓	×	×	✓
15	×	×	×	×	✓	✓
16	×	×	✓	×	✓	✓
17	×	×	✓	✓	×	✓
18	×	×	×	×	✓	×
19	×	×	×	×	✓	×
20	×	×	×	×	✓	×
21	×	×	×	×	✓	×
22	×	×	✓	×	✓	×
23	×	×	×	×	✓	×
24	×	×	✓	×	✓	×
25	×	×	✓	×	✓	×
26	×	×	✓	×	✓	×
27	×	×	×	×	✓	×
28	×	×	×	×	✓	×
29	×	×	×	×	✓	×
30	×	×	×	×	✓	×
31	×	×	×	×	✓	×
32	×	×	✓	✓	✓	×
33	×	×	×	×	✓	×
34	×	×	✓	×	✓	×
35	×	×	✓	×	✓	×
36	×	×	×	×	✓	×
37	×	×	×	×	✓	×
38	×	×	✓	×	✓	×
39	×	×	✓	×	✓	×
40	×	×	×	×	✓	×
41	×	×	×	×	✓	×
42	×	×	✓	×	✓	×
43	×	×	✓	×	✓	×
44	×	×	×	×	✓	×
45	×	×	✓	×	×	×
Total ✓	**13**	**1**	**28**	**7**	**39**	**8**

**from participants with Actiheart®, Actigraph™ and at least 3 days recalls using SNAPA™*
AH = Actiheart®, AG = Actigraph™, SNAPA™ = Synchronised Nutrition and Activity Program for Adults

Sedentary behaviour

Although not a primary aim in the development of SNAPA™ (and overlooked in development), the ability of the program to collect data on sedentary behaviour could be explored in the future.

Table 6.20 Light and sedentary activities (<3 METs) reported by participants

Activity	N	%
Walking (low)	47	66.2
Household tasks (low, medium)	38	53.5
Working on a computer	37	52.1
Driving a car	28	39.4
Watching TV/DVD	28	39.4
Shopping	23	32.4
Sitting talking, reading, writing, typing	22	31.0
Looking after children	15	21.1
Cooking	13	18.3
Sexual activity	9	12.7
Gardening (low)	7	9.9
Sleeping/napping	7	9.9
Standing reading, talking, filing	7	9.9
Reading	5	7.0
Talking on the telephone	5	7.0
Playing computer games – sitting	4	5.6
Playing a musical instrument	3	4.2
Riding in car/bus	3	4.2
Standing quietly	3	4.2
Watching a film at the cinema	3	4.2
Listening to music	2	2.8
Snooker	2	2.8
Writing	2	2.8
Yoga	2	2.8
Horse riding (low)	1	1.4

MET = metabolic equivalent

The mean number of minutes for all activities reported for the group was 336 minutes per day (5 hours, 36 minutes). The lowest daily mean reported was 15 minutes per day and the highest, 1016 minutes per day (16 hours, 56 minutes). Therefore, using the mean moderate to vigorous physical activity per day, approximately 274 minutes per day of light and sedentary activities was reported using SNAPA™. This leaves approximately 624 minutes (10 hours, 24 minutes), assuming an average sleeping time of eight hours, unaccounted for. However, participants were not instructed to report activities for every minute of the day.

Reported television viewing was low in this sample with just under 40% of participants reporting this activity (table 6.20), and only one participant reporting spending on average four of more hours watching television per day. In the most recent Health Survey for England, 26% men and 27% women reported spending four hours or more watching television on a week day, and this increased to 36% and 32% on a weekend day (Craig *et al.*, 2009). The mean number of minutes spent watching television per day in this sample was 52 minutes, compared with a mean of 2.8 hours on a week day and approximately 3 hours on a weekend day, as reported in the Health Survey for England (Craig *et al.*, 2009).

6.4.5. Feedback from participants

Results from the feedback questionnaire provided useful information from the participant's perspective of each method and identified important usability issues that can be addressed or considered in future studies.

Thirty participants responded to the feed back questionnaire. Responses to the feedback questionnaire were entirely confidential and not linked to any identifiable information; therefore it is not possible to report the demographics of the respondents.

Preferred assessment method

Participants were asked to rate each of the four assessment methods with a score from 1 to 4, with 1 being their favourite method and 4 their least favourite. Although ratings were varied, with all methods being rated in each category by at least one participant, the Actigraph™ monitor appeared to be the favourite assessment method with 42% rating this method as their favourite. Using the rating average score, the Actigraph™ was also ranked first. The highest proportion of the participants rated the lunchtime observation as their second favourite (32%), and this method was also ranked 2nd using the rating average score. The highest proportion of participants rated SNAPA™ as their third favourite/second least favourite method (33%), however the rating average score ranked this method fourth. Feelings were especially mixed for the Actiheart® monitor, with 30% of participants rating this method as their favourite method, and

30% rating it as their least favourite. The rating average score ranked this method third.

Good and bad things about each method

A number of themes were identified when exploring these free text answers. Some themes applied to all the methods, while some were method specific.

1. Wearing the monitors

A number of responses related to the physical activity monitors (both Actiheart® and Actigraph™) highlighted practical issues when wearing the monitors.

i) Monitor comfort

The biggest issue was reaction to the electrodes worn with the Actiheart® monitor, with the majority of the participants who responded to the feedback questionnaire (23 out of 30) commenting on this. The reactions were adverse for some (n=5) and in most of these cases the monitor was removed:

> *"I had a bad reaction to the electrodes so were removed within the first day leaving me with blisters and irritation for days"*
>
> *"my skin reacted quite badly to the patches used with them. This resulted in red swelling and terrible itchiness".*

The remaining participants had milder reactions mainly reporting itchiness (n=18):

> *"The electrodes were really itchy at times (especially while I was running) but nothing I couldn't cope with"*
>
> *"During the day it was ok but got noticed in the evening causing itching".*

Three participants commented that irritation was reduced when the electrodes were changed more regularly. However, two participants reported that discomfort when removing and replacing electrodes was a barrier against wearing the Actiheart®.

Another issue or barrier related to wearing the Actiheart® monitor was that the monitor caught in clothing and some participants were worried that it would come unattached (which it did in some cases). One participant found the monitor itself uncomfortable when sleeping:

> *"Sleeping was also a problem as I sleep on my left side so my sleep was disrupted for the week!!"*

Ten participants commented that the Actiheart® was discrete and unburdensome.

Many of the participants (n=15) commented that the Actigraph™ monitor was easy to wear, comfortable and was no burden. Seven participants commented that the monitor was uncomfortable or inconvenient in some way. One of these participants commented:

> *"my son kept hanging on the end of the elastic and twanging me with it!!"*

One participant also commented that the Acitgraph™ belt got sweaty when exercising.

ii) Monitor appearance

Monitor appearance was a bigger problem with the Actigraph™, with nine participants reporting unsightly appearance as barrier to wearing the monitor. In many of these cases reference was made to the monitor not complementing, or having to change, clothing:

> *"I chose to wear longer tops during the week so it was not visible"*
>
> *"(it) looked silly when going out (e.g. over smart clothes)"*

Although not reported in the feedback questionnaire, field notes and the monitor diary recordings show that in some cases the Actigraph™ was removed when the participant attended a special event (one example was a Christening) and was wearing smart clothing.

Fewer participants commented on the appearance of the Actiheart® (n=3) but it was an issue for them:

“didn’t want to go swimming with it attached because it would look odd”

“not good for love life! (doesn’t look hot…)”

2. Ease of use

The highest frequency of comments from participants about the Actigraph™ monitor stated that the monitor was easy to wear, comfortable and no burden (n=15).

The most common positive theme for SNAPA™ was that the program was straight forward and easy to use (n=8). Five participants commented that the program became easier to complete at each completion, however, two participants stated that they would not like to complete the programme for longer than one week.

In terms of problems when completing the program, five participants thought that there were insufficient food, drink and physical activity options to choose from, with one stating that a free text option would be useful. However, two participants stated that there was plenty of option choice. Three participants found the portion size estimation method limited and one participant commented that the advice sections of the program were not helpful. Five participants had connection issues to the program (one of these stated the issue with Internet Explorer version 8).

3. Time burden and convenience

The main barrier for SNAPA™ was that the perceived length of time it took to complete the program was too long (n=6):

“took AGES to do”

Three participants liked that the completion of SNAPA™ could be flexible in terms of time and location:

“I could do it in my own time at home”

Six participants stated that the lunchtime observations were a small commitment, easy to do and *“didn’t take up any extra time”*, however eight participants commented that it was a problem fitting in the observations with work and that it was inconvenient at times. Three participants did not like being observed while eating, although reasons why are unclear:

> *"Bad things: eating in view of cctv"* (In this quote it is assumed that cctv = researcher)

There were no negative comments on either activity monitor on the issue of time burden, with some participants commenting that an advantage of the monitors was that they *'didn't take up any time".* However, two participants commented that wearing the Actiheart® monitor 24/7 was inconvenient although the reasons why were not stated.

4. Memory

i) Remembering to wear activity monitors

Forgetting to wear the Actigraph™ monitor was a problem for many (n=14) and this appears to be to be the major barrier for this method. This was not a problem with the Actiheart® monitor due to the monitor being worn all of the time:

> *"didn't have to remember to do anything"*
>
> *"Not taking off meant I didn't forget to put it back on"*

A couple of participants also commented that not needing to take the Actiheart® off for water-based activities was a positive factor as reduced burden and chance of forgetting to reattach.

ii) Remembering to complete SNAPA™

One participant commented that remembering to complete the program was a problem, although they and one other participant found the email reminders useful.

iii) Remembering previous day behaviour

The most common issue when using SNAPA™ was the difficulty in remembering previous day behaviours (n=7), which is a problem for any recall method. Three participants also identified the difficulty of quantifying physical activities in terms of intensity.

5. Social aspect

A number of participants commented positively on the social aspect of completing the dietary observations, with nine remarking on the company of the research team and/or other participants:

> *"nice to meet [the researchers] and have a chat"*
>
> *"Good time to communicate with other participants"*

Four participants reported that they enjoyed stopping for lunch and having a break, which may not normally be the case:

> *"Good excuse to have a regular lunch break"*

6. Results and feedback

There was some concern that there was no way to tell if the Actiheart® was working or not, and in one case the monitor did fail which was disappointing for the participant:

> *"mine did not record so obviously wore for a week without results showing"*

The feedback from the Actiheart® was well received. One participant commented that wearing the *monitor "made me more aware of my physical activity levels"*, however it was unclear whether this was a result of receiving the feedback after the study or a 'reactive' effect of wearing the monitor during the study. The latter is a common concern when using monitors for the measurement of usual behaviour. Similarly, five participants stated that the completion of SNAPA™ made them more aware of both their dietary and physical activity behaviours, but again it was not clear if this was an effect of completing the program or feedback they received.

Participants did not receive any feedback about the dietary observation sessions. Three participants commented that taking part in the dietary observations made them more aware of what they were eating.

Four participants commented positively on the feedback received from the Actigraph™, however one commented that the feedback was less detailed compared with the Actiheart® and two were concerned about inaccurate results as a result of the inability of the Actigraph™ to measure activities such as cycling and rowing. One participant commented that the feedback received from SNAPA™ was inaccurate. Two participants liked that the feedback from SNAPA™ was *"detailed"*.

Perceived time taken to complete SNAPA™

Table 6.21 shows the time taken, on average, for each participant to complete SNAPA™. Only one participant found the program took longer than 30 minutes to complete, while the majority of the participants completed the program in 20 minutes or less.

Table 6.21 Responses to question 'approximately how long did it take you to complete SNAPA™, on average, each day?'

Time (minutes)	Number of responses (%)
5 – 10	9 (29.0)
15 – 20	17 (54.8)
25 – 30	4 (12.9)
35 – 40	1 (3.2)

SNAPA™ = Synchronised Nutrition and Activity Program for Adults

Suggestions for improvement of SNAPA™

The final question on the feedback questionnaire asked participants to suggest ways in which SNAPA™ could be improved. Twenty-three participants responded to this question. Some suggestions reaffirmed some of the comments made in the previous free text question on 'good and bad things' about SNAPA™. Table 6.22 displays the themes emerging from this question.

Table 6.22 Suggestions for the improvement of SNAPA™

Theme	Number of responses
More (and more detailed) food and/or activity options	9
More user-friendly/smarter data entry	7
No improvement required	5
Ability to type in ‘other’ options	4
‘Work day’ and ‘weekend’ distinction	1
Reporting activities before food useful	1
Segmenting day not helpful	1
Waking/bedtime	1
Improve aesthetically	1

SNAPA™ = Synchronised Nutrition and Activity Program for Adults

6.5. Discussion

6.5.1. Accuracy of SNAPA™ against criterion methods

The results from this study indicate that SNAPA™ shows reasonable agreement with the criterion method at a food item level with relatively high match rates and relatively low phantom rates reported. Surprisingly, the most commonly forgotten foods tended to be the ‘healthy’ (or perceived ‘healthy’) foods: fruit, vegetables and yogurt, with bread, rice and potatoes also forgotten by a small proportion, while the most common phantom foods were chocolate, sweets and biscuits. This is in contrary to the concept that individuals tend to over-report ‘healthy’ and under-report ‘unhealthy’ foods. Results from the food item agreement analysis are difficult to compare with other studies, as, to my knowledge, no other studies have performed diet observation of adults in free-living settings, although a number have been carried out in a research centre setting (for example, Conway *et al.*, 2003; Conway *et al.*, 2004; Beasley *et al.*, 2005), or reported food item agreement in adults. In lunchtime observation studies in children, match rates between 46% and 70% (Baranowski *et al.*, 2002; Baxter *et al.*, 2002; Baxter *et al.*, 2007; Warren *et al.*, 2003), and phantom (or intrusion) rates between 24% and 54% (Baranowski *et al.*, 2002; Baxter *et al.*, 2002; Baxter *et al.*, 2007) have been reported. Results from this study show higher match rates and lower phantom rates; however, protocols and analysis were not identical between the studies and it may be expected that adults are able to recall behaviour more accurately than children.

SNAPA™ also showed reasonable concurrent validity at the nutrient level with correlations ranging from 0.39 to 0.56, similar to those found in other studies (Arab *et al.*, 2009a; Bingham *et al.*, 1994; Vereecken *et al.*, 2010; Zoellner *et al.*, 2005), although lower than those reported in a study evaluating the DietMatePro also using lunchtime observation as a reference method (Beasley *et al.*, 2005). Biases were identified for the measurement of energy intake and fat intake in terms of grams. No biases were indentified for the primary outcomes of interest: percentage food energy from fat and fruit and vegetable intake, with almost perfect agreement for the latter. The strongest agreement for fruit and vegetable intake may be due to less error being associated with the one-stage recall of 'portions' compared with the process of using an estimated or average portion size of whole foods, then assigning an appropriate nutritional values for the calculation of fat and energy intake, with errors associated with each stage.

The precision of SNAPA™ and the individual level was also explored in this study and the findings can be compared with the study evaluating the DietMatePro, a dietary recall program administered on a personal digit assistant (PDA), in an adult population using a lunchtime observation as a reference method for dietary intake (Beasley *et al.*, 2005). Using the Bland-Altman method, comparing lunchtime energy intake reported with observed intake revealed a mean overestimation using the DietMatePro of approximately 0.4 MJ, greater than observed in this study. The width of the limits of agreement (±2 standard deviations) was approximately ±1.5 MJ, similar to that observed in this study, and would be considered broad for this variable indicating low precision at an individual level. The main difference between the study and the one reported in this chapter is that only one lunchtime observation was carried out in the DietMatePro evaluation (Beasley *et al.*, 2005). Broad limits of agreement have also been observed in a number of other method comparison studies using self-report methods (Conway *et al.*, 2002; Conway *et al.*, 2003; Conway *et al.*, 2004; Jonnalagadda *et al.*, 2000; McLure *et al.*, 2009), for both diet and physical activity assessment, demonstrating the difficulty in achieving accurate measurement at the individual level.

Results from the method comparison analysis show that SNAPA™ appears to overestimate lunchtime intakes. However, when comparing overall intakes with national levels (Henderson *et al.*, 2002; Henderson *et al.*, 2003), and total energy expenditure estimated by combined heart rate and accelerometry, it appears that SNAPA™ underestimates intake (and to a greater extent in men). It is unknown when the counteracting error occurred, i.e. if a specific meal is under-reported or if due to an under-reporting of snacking or a combination of both. This highlights the weakness of the use of dietary observation as a criterion method, as only a small, specific time period can be observed.

SNAPA™ also showed reasonable concurrent validity when compared with combined heart rate and accelerometry, with correlations of 0.27 and 0.44 similar to other studies (Albanes *et al.*, 1990; Craig *et al.*, 2003; Matthews *et al.*, 2000; McMurray *et al.*, 1998; Ridley *et al.*, 2001; Welk *et al.*, 2004); however, biases were identified. It may have been expected that there would be a higher agreement between the methods when comparing SNAPA™ data with the Actiheart® 10 minute bout data as when completing SNAPA™, participants were instructed to complete activities carried out for at least 10 minutes. After the removal of the high leverage (influence) point, the correlation between SNAPA™ and the Actiheart® was lower when the 10 minute bout criteria was applied, compared with the correlation when all minutes were used. When all participants were included in the Bland-Altman analysis, the mean difference between the methods were a similar magnitude for both criteria, although SNAPA™ underestimated compared with all minutes of moderate to vigorous physical activity determined by the Actiheart®, and overestimated compared to minutes carried out on bouts of 10 minutes or more. The width of the limits of agreement was slighter smaller for the 10 minute bout comparison. Further exploration of the SNAPA™ raw data revealed few instances (n=12) where participants reported activities for less than ten minutes and on only two occasions was the activity reported a moderate to vigorous physical activity (swimming and running). When the all minutes of moderate to vigorous physical activity criteria was used in the individual level analysis, similar patterns and width of the limits of agreement were observed in this study to those reported in chapter four and the peas@tees study (McLure *et al.,* 2009).

There was a lack agreement between SNAPA™ and accelerometry alone in this study. In the preliminary method comparison study (chapter four), data for the non-ambulatory activities (cycling, weight training and standing manual tasks) and swimming that had been collected from SNAPA™, were excluded from the comparison analysis, and this could be repeated using this dataset. It is predicted that the errors involved in capturing lifestyle activities, using both methods, will be a major contributor to the between method differences, and these activities are difficult to control for. Therefore, the lack of agreement is not surprising and it must be remembered that the primary method comparison was between SNAPA™ and the combined heart rate and accelerometry method.

In this study, only three instances of over-reporting were identified over all of the days of data collected. Although SNAPA™ was completed remotely without assistance of researcher, participants did have a great deal of contact with the researcher through the pre-study meeting, study set-up and lunchtime observations. This connection with the research team may have caused, subconsciously or consciously, participants to be more careful when completing the program.

The biggest weakness identified, through the food item agreement analysis and the feedback from the participants, is the limited food item and activity options. As well as causing frustration for users, this limitation will no doubt be affecting the accuracy of the data collected. Expansion of the option lists, as well as grouping and searching strategies, will be explored and incorporated in any new versions of SNAPA™.

6.5.2. Limitations of criterion methods

As discussed in chapter one of this thesis, measuring exact dietary intake is extremely challenging and a true ‘gold standard’ method does not exist. This study aimed to overcome the errors involved in comparing a self-report method against another self-report, albeit one considered a ‘standard, reference’ method.

Although direct diet observation is also a subjective method, it is carried out prospectively by trained observers, eliminating memory and subject associated biases; so is considered a suitable reference method for the validation of self-reported methods (Mertz, 1992). It can be used on a relatively limited budget and does not require specialised equipment or facilities. However, direct diet observation does have limitations and, although used successfully with children in school settings, it is difficult to replicate in adults. School children are accustomed to eating lunch at a specified time (lunch break), in a specified location (dinner hall), in the presence of adults (teachers; canteen staff). In addition, the large number of children present during lunchtimes assists in diluting the novelty of new and additional personnel being present, and also allows the use of blinding techniques (i.e. each child will be aware that they will be observed during a certain time period, but will not on which specific days). Finding an equivalent population of adults is difficult and consequently the use of direct diet observation was the main deciding factor when identifying the target study population.

Workplaces and further education institutions (where both staff and students could be approached) appeared to offer a promising adult equivalent of schools, where staff members (and students) have scheduled lunch breaks and specified eating areas. Of course in the real world, these institutions are much more dynamic and less structured than school settings. Lunchtimes are much less structured and in most cases do not have a strict time constraints, with staff being flexible when taking breaks, depending on situations of the day. Although advised to do so, many staff members do not eat their lunches in provided eating areas, but will remain at their work station/desk. Part-time and shift workers are not always present at lunchtimes, nor are students, who may have only a few hours of structured contact-time in college. Lunchtime meetings are also a barrier to accessing some staff during this time.

When used for the purpose of validation, a main objective of direct diet observation is to keep situation as normal as possible to prevent recall being enhanced by an ‘event’ effect where the behaviour is associated with a special occasion and, therefore, more distinct (enhancing recall using episodic memory). However, this was not always possible in this study. Participants were asked to eat at a place where researchers could observe a group of people as it would have been logistically very difficult to observe each participant at their usual eating location (in most cases at their desk). Therefore in many cases, participants were eating their lunch in different locations than usual and, in some cases, with different people than usual. In addition, it was often the case that very small groups (and in some cases single participants) were being observed, which not only heightened the ‘event’ effect, but also may have caused some embarrassment and discomfort; again adding emphasis to the eating ‘event’. Participants were also very aware of who was observing them in the situation, and researchers did make conversation with participants, as the comfort and well-being of the participant was believed to be a priority.

Another weakness in the observation method used in this study is that observers were identifying pre-made meals, often brought from home; therefore it was difficult to identify and quantify portions sizes for hidden items such as spreads and fillings in sandwiches, sugar added to drinks and any fat added during cooking/preparation. Asking participants to describe their foods may help provide this extra detail but may, in turn, enhance recall and affect any method comparison results. As a result of these limitations, packed lunches are sometimes excluded from observation in children studies because of the difficulty of determining all of the contents (Baranowski *et al.*, 2002).

There are few examples of observation studies in adults in the literature; therefore it is difficult to interpret the results of this study comprehensively. Observation studies in adults have also mainly been carried out in controlled conditions where participants are invited into a laboratory or research centre to consume meals. For example, Conway and colleagues used this approach for the evaluation of the multiple pass recall dietary interview (Conway *et al.*, 2003; Conway *et al.*, 2004). As previously discussed, consuming food items in an unusual environment (more unusual than a different eating location at a workplace) may cause the eating occasion to be more distinctive and memorable, thereby enhancing recall.

A further weakness in this study is that I carried out the coding and data entry of the observation data, which may have affected (although unintentional) how foods were coded and subsequent nutritional values due to my personal involvement in this work. Using blinded data coders would have helped to ensure unbiased data coding and added strength to the study.

For future evaluation work it may be worth exploring the use of the truer criterion methods, biomarkers or duplicate diets. However, there are still a number of limitations associated with these methods and the advantages may be outweighed by limited budgets, resources and expertise.

For the physical activity assessment, the main limitation associated with the objective activity monitors used as reference methods was subject compliance. Compliance was higher with the accelerometer units, with more participants providing this data. However, of those who did provide combined heart rate and accelerometry data, more complete data were provided (i.e. all seven days requested). Compliance is discussed in more detail below.

As discussed previously, another major limitation of accelerometery is the inability to capture non-ambulatory activities accurately, and activities where the monitor is removed. Although, there is no need to remove, the ability of the Actiheart® monitor to measure swimming is not established. Swimming provided, on average, a small contribution to overall minutes of activity in this sample (from the self-reported data), but it is a popular activity; reported second most popular activity and second most frequent in the General Household Survey (Fox and Rickards, 2004).

6.5.3. Compliance

Two participants could not complete SNAPA™ because they were using the latest version of Internet Explorer (version 8) with which SNAPA™ was incompatible (and also affected its use in other web browsers on the same computer, for example Mozilla Firefox). This problem highlighted the importance of continued computer programming support when using internet-based assessment methods of this type to ensure compatibility with new internet technologies. At the time of this primary method comparison study, computer programming support was limited and the compatibility problem could not be resolved. In this study, only two participants were affected; however, in future studies it would be expected that a higher proportion of the population will be using Internet Explorer version 8 and possibly new versions of other web browsers.

Four other participants, with no known IT issues, did not complete SNAPA™ at any time during the study, despite signing consent form stating that they understood what was involved in the study, being sent email reminders and given verbal reminders during diet observation. Participants were not pressurised to complete the program, however, as non-compliance was a factor of interest in this study. These participants were all workers from the Garden Centre and, although they had access to a computer with internet access, they did not use computers and/or the internet regularly as part of their job. Through anecdotal feedback given at the end of the study, it was clear that lack of computer skills and/or opportunities to use the internet were barriers to completing SNAPA™. For the remaining participants compliance in using SNAPA™ was reasonable.

The direct diet observation component of this study was the most difficult for participants to adhere to with nearly 30% of the participants failing to attend these sessions and only 17% completing all four requested sessions. Reasons for non-attendance included attendance at lunchtime meetings, sickness absence, and that some participants were part-time or shift workers and were not in work during all the lunchtime sessions. For those participants who were part-time and shift workers, I was informed of the problem during the pre-study interview. This issue caused a dilemma as to whether to exclude the participant from the study. However, the exclusion of part-time or shift workers was not specified on the participant information sheet and excluding such participants who, although they could not provide a complete dataset, could nevertheless provide most of the data required. It was decided that their exclusion, on balance, would result in the loss of more data overall.

Another dilemma faced was the issue of the incentive given in relation to the compliance of the participant. In this study the full incentive of £30 high street shopping vouchers was given regardless of the amount of data provided by the participant. In future studies some thought may be given to staggering the incentive related to the amount of data collected. On the other hand, introducing such a strategy may be difficult to implement and establish cut-points, as well as have ethical implications. For example, would it be fair to punish a part-time worker who may show full compliance to the components of the study they are able to complete, and perhaps more, by stopping back late or coming in before their shift to have their activity monitors fitted, but were unable to attend three out of four lunchtime observation sessions as they did not work on those days? In free-living studies, participants will always have different issues and circumstances, and this will always be the nature of this type of research. I believe we need to trust that each participant has participated to their full ability.

The main reason for non-compliance with the Actiheart® monitor was adverse reactions to the electrodes. This was quickly apparent from comments and complaints made to the research team, starting with participants from the first study group. This issue was also one of the main findings from the qualitative feedback. Participants were all reminded at the time that they could remove the Actiheart® and electrodes at anytime if they were causing discomfort. Solutions were also explored, and anecdotal evidence suggested that changing the electrodes more regularly, reduced itchiness and reaction. The electrodes initially used were the Unomedical Unilect™ 4060M (ConvaTech, Uxbridge, UK). After consultation with the Actiheart manufacturer, CamNtech, a different make/model of electrode (Maxsenor dry gel MXC55 ECG Electrodes; Pulse Medical Limited, Surry, UK) was used, which resulted in fewer reactions and complaints. Both electrodes are approved for use by CamNtech, and using either type will not affect the overall results from the Actiheart® monitor.

The prevalence results of participants meeting the government recommendations for physical activity highlights the importance of compliance as missing data will result in unrepresentative results (those who meet the recommendations but have incomplete data may not be counted). A weakness of the analysis used in this study is that all participants who had at least one day of data were included in the prevalence analysis and thus will have resulted in an under-estimation of prevalence. However, this analysis was for investigative purposes only and not a primary objective of this piece of work. In the Health Survey for England, only participants who had a complete set of seven days of accelerometry, were included in the prevalence analysis (Craig *et al.*, 2009). In the Health Survey for England, 49% of men and 46% of women wore an accelerometer for at least 600 minutes per day on at least four days. 53% of men and 51% of women provided at least one valid day of data, and 31% of men and 27% women provided the full seven days. Compliance in the current study, in comparison, appears to be high, though of course it would be expected in a smaller, focused study.

6.5.4. Physical activity prevalence

The prevalence data also shows that it cannot be assumed that participants categorised as 'active' by a reasonable criteria (i.e. mean minutes of moderate to vigorous physical activity per day; mean number of steps per day) will also meet the recommendation 'at least five a week' criteria. This also highlights the limitations of the 'at least five a week' criteria as it does not take into account individuals who carry out more than 30 minutes moderate to vigorous physical activity on some days. For example, an individual may only have achieved 30 minutes or more moderate to vigorous physical activity on four days of the week, but on one of those days they achieved more than one hour of moderate to vigorous physical activity (in at least 10 minute bouts). Physiologically, is carrying out 60 minutes of moderate to vigorous physical activity on one day different from carrying out 30 minutes on two days? Variations in physical activity classifications, depending on criteria used, is demonstrated by Thompson and colleagues (Thompson *et al.*, 2009) in a sample of 90 middle-aged men. There was poor agreement between various physical activity recommendations, with the proportion classified as 'active' ranging from 11% to 98% depending on the criteria used.

No screening criterion was used for the Actiheart® data in respect of loss of heart rate data during the measurement period as no consensus on dealing with lost heart rate data has been established. During the processing of the data the 'automatic data fill' offered by the Actiheart® software was not applied.

6.5.5. Sampling bias

A weakness of this study was that it relied on a volunteer sample which may not have been fully representative of the population for which SNAPA™ is targeted. It was obvious that the study attracted some highly motivated individuals who were particularly interested in physical activity and sport and/or diet. There was also a group of students who were recruited from a sports based course at a local college. It was, therefore, expected that overall the study sample would have higher levels of physical activity than the national average. On the contrary, this did not appear to be the case and overall prevalence data was comparable with the recent Health Survey for England data. A few participants did comment that the vouchers were the main incentive for them participating so this strategy may have been effective in attracting less motivated people. Although unintentional, there were some snowballing effects seen in the recruitment where one individual would see the study advertised (email at work) and pass on the information to other colleagues (and possibly encourage them to take part). It was ensured, however, that each participant was fully aware of the requirements of the study, was not coerced to take part and that fully informed consent was given. Taking part as a group may have created a supportive, less isolated environment, and certainly appeared to be a facilitator to participation for some.

6.5.6. Qualitative themes

The qualitative work in this study was not a focussed, in depth investigation. However, this work provided a useful basis for future evaluation work. Some themes were generated by only a small number of statements; although, more participants may have identified certain issues if they had been asked about them directly. In work exploring usability issues of future versions of SNAPA™ more specific questions could be asked based on the themes identified in this work, in addition to free text questions.

Chapter Seven: Final discussion and conclusions

7.1. Summary of results from thesis studies

The results of the evaluation work carried out for this thesis indicate that SNAPA™ is a promising tool for measuring specific energy balance related behaviours at a group level in adult populations; however, further development and evaluation is needed to eliminate the biases detected. The precision of the tool at an individual level was low; however, as will be discussed in the following text, this is similar to findings in evaluations of other self-report methods of both diet and physical activity assessment. Precise measurement using self-report tools may be hard to achieve because of the errors associated with them.

Comparisons with other studies is difficult due to huge range of different protocols and analyses carried out and there are currently no other computerised tools exist, to my knowledge, which collects diet and physical activity data simultaneously in adults, for direct comparison. However, loose comparisons can be made against the current literature, and I believe that the evaluation findings of SNAPA™ are comparable with evaluations of other self-report assessment tools.

In terms of diet, in a study by Bingham and colleagues, two food frequency questionnaires and two types of 24 hour recall (structured and unstructured) methods were compared against the reference method 16 day weighed food records (Bingham *et al.*, 1994). Correlations for macronutrients ranged between 0.13 to 0.90, with correlations between 0.32 and 0.52 for energy and 0.35 and 0.55 for total fat intake (Bingham *et al.*, 1994), all comparable to those reported in chapters four and six. The evaluation of a food frequency questionnaire administered in the European Prospective Investigation into Cancer and Nutrition, revealed correlations (unadjusted for energy) between 0.47 and 0.88 for macronutrients, when compared against 24 hour recalls (Kroke *et al.*, 1999). Correlations of 0.61 and 0.59 were observed for energy and fat intake, respectively (Kroke *et al.*, 1999), slightly higher than those reported in chapters four and six.

The results from chapter six of this thesis are more directly comparable to findings from the study evaluating the DietMatePro, a dietary recall program administered on a personal digit assistant (PDA), in an adult population using a lunchtime observation (Beasley *et al.*, 2005). In this study higher correlations than were reported in chapter six were observed for lunchtime energy and fat intakes (grams), 0.72 vs. 0.55 and 0.51 vs. 0.39, respectively. In the same study, the PDA system was also evaluated against a 24 hour dietary recall. Whole day diet correlations ranged between 0.51 and 0.80 and for dietary variables in this study, higher than those observed in chapter five (between 0.42 and 0.48). However, the variables were not directly comparable with the variables measured by SNAPA™ in the preliminary method comparison study in chapter five (percentage of food energy from fat and fruit and vegetable portions).

This study also investigated precision of the DietMatePro at an individual level, using Bland-Altman plots (Beasley *et al.*, 2005). The comparison between lunchtime energy intake reported and observed revealed a mean overestimation of energy intake using the DietMatePro of approximately 0.4 MJ, greater than observed in chapter six, although in this study only one day of data were collected, with the width of the limits of agreement (±2 standard deviations) approximately ±1.5 MJ, similar to that observed in chapter six. Bland-Altman plots were also displayed comparing whole day energy intake reported using the DietMatePro against energy intake reported using a traditional 24 hour recall method. The mean difference between the methods was close to zero, and the limits of agreement ranged from -6.9MJ to 8.3MJ, where a negative value indicates underestimation. However, this data is not comparable with the findings in chapter four of this thesis as whole day energy intake is not reported.

Other method comparison studies that have investigated individual level precision, and illustrate the imprecision of self-report methods similar to SNAPA™ at the individual level, include studies evaluating the multiple pass recall dietary recall interview. In a study in women comparing the multiple pass recall dietary interview against known intakes (observed in a research centre setting) mean differences between the methods for energy intake and fat intake were 0.69MJ and 4.8g, respectively (Conway *et al.*, 2003). For energy intake, Bland-Altman analyses revealed limits of agreement of approximately -2.2 to 3.7MJ, where a negative value represents underestimation by multiple pass recall dietary interview (Conway *et al.*, 2003). In a similar study, this time in men, the mean differences between methods for energy and fat intake were 1.03MJ and 9.6g, respectively (Conway *et al.*, 2004). For energy intake, limits of agreement were approximately -2.9 to 6.3MJ (Conway *et al.*, 2004). In both studies, the mean difference and limits of agreement are larger than reported in this chapter for energy intake; however, this is to be expected as whole day dietary intake is being evaluated as opposed to one meal. In contrast, the mean difference between the methods for fat intake in grams is actually smaller in the study in women (Conway *et al.*, 2003), than reported in chapter six (4.8g versus 6.3g).

In another study evaluating the multiple pass recall dietary interview, also using know dietary intakes (provided diets eaten in supervised and free-living settings), in men and women, the mean difference between methods for energy intake was 0.93MJ during a controlled diet period and 1.39MJ during a self-selected diet period (Jonnalagadda *et al.*, 2000). Limits of agreement ranged from approximately -6.8 to 2.8MJ (controlled diet period), and from approximately -7.6 to 5.5MJ (self-selected diet period) (Jonnalagadda *et al.*, 2000).

In terms of physical activity, there are a number of examples of method comparison studies evaluating self-report methods reported in the literature all reporting findings comparable to those reported in chapters four and six. Albanes and colleagues evaluated eight commonly used physical activity questionnaires against know energy intakes and reported correlations of between 0.13 and 0.49 (Albanes *et al.*, 1990). In a study evaluating the Baeke Questionnaire against 24 hour physical activity recalls, correlations ranged from 0.29 to 0.52 for different domains of physical activity (total, household, occupational and leisure-time) (Matthews *et al.*, 2000). In a study in fifth-grade children (10 to 11 years of age), the Previous Day Physical Activity Recall (PDPAR) method was evaluated using accelerometry (Trost *et al.*, 1999). For minutes of activity reported rated at 6 METs or above, a correlation of 0.38 was reported, but for activities rated at 3 METs or above, a lower, non significant correlation of 0.19 was observed (Trost *et al.*, 1999). In another study in children aged 7 to 12 years, correlations between relative energy expenditure derived from the PDPAR, and pedometer and accelerometry counts were 0.88 and 0.77 respectively (Weston *et al.*, 1997). The findings from a number of evaluation studies carried out in adults during the 1970's and 80's are summarised in the review by Sallis and Saelens (Sallis and Saelens, 2000). Correlations reported ranged from 0.02 to 0.67 for various domains of physical activity (Sallis and Saelens, 2000). Reference methods used in these studies were either accelerometry or known energy intakes.

In a method comparison of energy expenditure estimated by a physical activity questionnaire and physical activity records, using energy expenditure determined by doubly labelled water as the criterion method, mean biases reported were 0.91MJ and 4.12MJ respectively (Conway *et al.*, 2002). For the physical activity record estimated energy expenditure, the 95% limits of agreement were approximately 3MJ to -5MJ, where a negative value indicates an overestimation. For the physical activity recall estimated energy expenditure, the 95% limits of agreement were approximately 5MJ to -12MJ, with the negative trend reflecting major overestimations of energy expenditure using the recall method by several participants (Conway *et al.*, 2002). Although this study is not directly comparable to the findings in this thesis, it does demonstrate the imprecision of self-reported physical activity at an individual level, especially using recall.

Evaluation results have been reported for many of the computer and/or internet-based assessment programs reported in chapter one (section 1.6.), although not all. A number of these studies may be compared with the results of these thesis. In the study evaluating the Billingual Interactive Multimedia Dietary Assessment against 24 hour recall), correlations (unadjusted) of 0.44 and 0.43 were reported for total fat intake (Zoellner *et al.*, 2005), comparable with findings from chapter four, although percentage of food energy from fat was the variable in this case. Higher correlations were reported for vegetable servings, 0.61, and fruit servings, 0.82, compared with 0.42 reported in chapter four for portions of fruits and vegetables combined (Zoellner *et al.*, 2005).

In a study by Blanton and colleagues, the USDA Automated Multiple-Pass method, along with the Block Food Frequency Questionnaire and NCI Diet History

Questionnaire, were evaluated against doubly labelled water (reference method for energy intake) and 14 day estimated food records (reference method for macro and micro nutrient intake; and was also evaluated against doubly labelled water in terms of energy intake) (Blanton *et al.*, 2006). For energy intake, using the Bland and Altman method, the Automated Multiple-Pass method demonstrated a bias close to zero (77kJ), with an equal distribution of individuals above and below the mean bias. The food record method underestimated energy intake by a mean of -489kJ, and the Block Food Frequency Questionnaire and NCI Diet History Questionnaire, underestimated energy intake by means greater than -2500kJ. Unfortunately, these results are not comparable with the findings in chapter four of this thesis as whole day energy intake is not reported bit again demonstrate the imprecision of some common self-report methods.

In the validation of the DietDay dietary assessment program using doubly labelled water, correlations ranged between 0.07 and 0.44 when 2 days of data were used, and between 0.25 and 0.56 for 7 days (Arab *et al.*, 2009a). The Young Adolescents' Nutrition Assessment on Computer (YANA-C) was evaluated in two studies, one using food records as the reference method and the other using 24 hour dietary recall (Vereecken *et al.*, 2005). For energy and nutrient intakes, correlations ranged between 0.44 and 0.79 (YANA-C versus food records) and between 0.44 and 0.86 (YANA-C vs 24 hour recall), with correlations of 0.58 and 0.59 for fat intake, in each study respectively (Vereecken *et al.*, 2005). The Young Children's Nutrition Assessment on the Web (YCNA-W), a program that is completed by parents of young children, was evaluated against a food frequency questionnaire (Vereecken *et al.*, 2010). Correlations between the methods ranged between 0.32 and 0.59, for energy and nutrient intakes, with correlations of 0.40 and 0.45 for grams of fat and percentage of energy from fat, respectively (Vereecken *et al.*, 2010). Bland Altman analysis revealed broad limits of agreement between the methods, for example approximately -9MJ to 16MJ for energy intake (FFQ – YCNA-W) (Vereecken *et al.*, 2010).

All of the computer-based tools reported in chapter that assess physical activity levels were designed to be used in children. Evaluations of the Children's Activity Recall, CDPAQ, and MARCA, all using accelerometry as the reference method, revealed correlations of 0.58 for energy expenditure for the Children's Activity recall (McMurray *et al.*, 1998), and 0.36 and 0.35 for the CDAPQ and MARCA respectively for the measurement of moderate to vigorous physical activity (Ridley *et al.*, 2001; Ridley *et al.* 2006). The Children's Activity Recall also reported approximately 26 more minutes of moderate to vigorous physical activity than determined by accelerometry (McMurray *et al.*, 1998). In the evaluation study of the ACTIVITYGRAM versus accelerometry, correlations between 0.33 and 0.50 were reported for bouts of physical activity (Welk *et al.*, 2004).

Finally, some comparisons can be made between the findings in this thesis and with the previous Teesside University and Durham University tools peas@tees and SNAP™. In the evaluation of the peas@tees tool, correlations of 0.23 and a bias of 21 minutes underestimation were reported for the estimation of moderate to vigorous physical activity, using accelerometry as the reference method (McLure *et al.*, 2009). In the primary evaluation of SNAPA™ (chapter six), a correlation of 0.27, and a bias of 22 minutes overestimation due to a substantial proportional bias, were reported using the more accurate combined heart rate and accelerometry method as the reference method, and using the criteria where only minutes of moderate to vigorous carried out in bouts of 10 minutes or more were included in the analysis (the criteria used in the government recommendations for physical activity (Department of Health, 2004)). Compared with these findings, the SNAP™ tool appears to be more accurate than SNAPA™, overestimating minutes of moderate to vigorous physical activity by only 9 minutes and revealing no substantial fixed or proportional biases; however in this study, one-day accelerometry was used as a reference method (Moore *et al.*, 2008).

The SNAPA™ tool appears to be more robust in the assessment of dietary behaviour than physical activity. It may be that food items and meals are easier to define than time spent doing a physical activity at a certain intensity. One potential source of error may be that activities can be clumped together with start and end points not actually corresponding with the activity being recalled. For example a person cycling to work may define the start of that activity as the time they leave the house to the time they sit at their desk, which may be 30 minutes, although the actual time spent cycling was 25 minutes. However, despite the availability of objective measurements, self-reported physical activity data is important for surveillance as it adds context to the objective data. Self reported physical activity data can also better capture certain types of activities, compared with objective monitors. Combining SNAPA™ and an objective measurement of physical activity (for example accelerometry) may be a promising approach and worth investigating in the future.

One of the aims of this work was to develop a method that reduces burden for participants. The time taken to complete SNAPA™ was for most people less than 30 minutes, a similar amount of time as it takes to complete other computer programs that collect data on either diet or physical activity. Although feedback from participants indicates that some people found the program time consuming to complete, this may be have been a perceived problem regardless of the self-report method used. In this study SNAPA™ was not compared to any other self-administered assessment tool, therefore the incorporation of this type of comparison into future evaluation work would explore this issue in relation to similar methods.

The burden on researchers is also much lower when using SNAPA™ compared with other methods, in particular the reference dietary assessment methods (24 hour multiple pass recall dietary interviews and dietary observation). Currently, processing group data collected by SNAPA™ takes approximately half a day, although further programming can potentially make this process more instant. For the dietary assessment reference methods, researchers could spend half a day coding data collection sheets and inputting data into nutritional software for just one participant.

The level of agreement between SNAPA™ and reference methods (24 hour multiple pass recall dietary interviews, dietary observation, accelerometry and combined heart rate and accelerometry) has been explored in relatively controlled environments and situations. Although additional work has also given some indication of the feasibility of using SNAPA™ in different environments and situations, further work is now needed to explore the concurrent validity of

SNAPA™ in these conditions. SNAPA™ also showed reasonable short-term reliability; however reliability over longer periods is unknown.

7.2. Improvements for future versions of SNAPA™

The evaluation work described in this thesis has provided invaluable information for the future development of SNAPA™. The program as it stands is relatively simple and not as sophisticated as some other programs currently available (described in chapter one). During the development of SNAPA™, strategies identified from the literature, such as segmenting and encoding, were incorporated; however there are still a number of features and processes that were not, especially in terms of the automated processes that can be exploited when using computerised systems. A number of strategies were identified during the planning stage but because of time constraints and limited computer programming support, they could not be included in the current version of the program. It is also important to note that the current version of SNAPA™ was originally designed for use in the 'Get a Better Life' campaign in conjunction with the campaign website, therefore some features (or lack of) are a consequence of this. Further development work is planned that will incorporate findings from this thesis and be informed by good practice demonstrated by other programs of its type.

The following list includes a number of features and strategies that will be explored in future versions of SNAPA™, which are then described in more detail:

- More user-friendly interface
- More comprehensive food and physical activity lists
- Smarter search strategy for food and activity items
- Additional probing for information on fats
- Addition of waking and sleep times
- Improved physical activity duration reporting method
- Automatic data checks
- Additional modules
- Improved researcher control
- Neutral design
- Save-as-use capacity

- Reporting occupational activities
- Optional audio instructions

More user-friendly interface

A number of participants commented that some of the processes involved in SNAPA™ were quite laborious for the report of a relatively small amount of information. Some participants also did not find the program ‘engaging’. The interface of a program designed for large and varied populations, with a range of IT skills and competencies, is extremely challenging. This issue will be explored in conjunction with experts in computer programming and human-computer interaction, to identify alternative processes that are more engaging, but remain easy to follow for those with limited IT skills. The acceptability of these processes can then be explored through usability testing.

More comprehensive food and physical activity lists

A number of ‘missing’ food and activity items were identified throughout the evaluation work. Providing more items will improve accuracy (less reliance on closest match) and reduce frustration for the user. Some participants were frustrated that a free text option was not available. As SNAPA™ is designed to provide faster/instant data analysis; this option is not feasible as it would involve additional coding and processing. Clear explanation of this issue to users in an optional additional information format (for example a help section or ‘frequently asked questions’ section) may reduce some frustration. The addition of a comments box where missing items could be reported and used to inform revised versions of the program may be a useful, streamlined approach (in this current work this information was collected separately through feedback to me).

Smarter search strategy for food and activity items

The expansion of food and activity item lists described above will, in turn, create the need for a smarter method of finding the desired item, as searching through a long list of items can be tedious for the user. Strategies such as searching items in categories and free text searches have been successfully incorporated into other programs and will be explored in further developmental work for SNAPA™.

Additional probing for information on fats

Information on small, additional items such as spreads added to bread; oils and dressings on salads, and added sauces are sometimes overlooked in dietary intake recall. Providing options with their commonly combined high fat extra (e.g. toast and butter) appeared to be a useful strategy in terms of reducing participant burden. The incorporation of other common combination item options will be explored. Additional questions on fat such as fat trimmed from meat may also improve the recall of fat intake.

Addition of waking and sleep times

SNAPA™ does not currently ask participants to report the time they woke up or went to sleep. This information may act as additional anchors for the day to improve recall and could also be used to estimate sedentary time.

Improved physical activity duration reporting method

In the current version of SNAPA™, users are asked to report the time that they start and finish the reported activity. This information is then used to calculate the duration of the activity. This innocuous question, proved to cause the biggest problem from the researchers' perspective. There were a number of instances when the reported finish time was a time preceding the start time, resulting in durations of negative values which then had to be corrected during the data cleaning process.

Another common mistake occurred when users reported activities that spanned over the morning and afternoon segments of the day. In each day segment, only time options specific to that time period were provided, for example in the afternoon section participants could only report times from the hours 12 to 6 (representing 12pm/noon and 6pm). In the morning section participants could report times from the hours 0 to 12 (representing 12am/midnight to 12pm/noon). Therefore, for activities that began during the morning but finished after 12pm, some instances occurred when the 'am' times were incorrectly used as finish times, again resulting in a negative duration. For example, if an activity that began at 11am and finished at 1pm is reported in the morning section, the hour '1' selected is incorrectly coded as 1am. The correct way to report this activity would be to report the first hour in the morning section of SNAPA™ (11am to 12pm) and the second hour in the afternoon section (12pm to 1pm). This demonstrates a weakness of using the segmented day format as more effort is required to report such activities.

A 24 hour clock format could be used to avoid confusion. However, difficulties using this format were identified in the usability testing where some users still chose ‘am’ times instead of ‘pm’ times. Labelling times ‘am’ and ‘pm’ may be another alternative. Automatic data checks could also be incorporated to identify if a finish time reported precedes the start time. Another, approach could be to ask users to report the start time and then how long the activity lasted. This approach may also control for over-reporting activities if the duration options has a maximum time limit (e.g. 3 hours). However, this may cause frustration if an activity is genuinely carried out for longer than the maximum allowance.

Automatic data checks

In addition to an automatic check that ensures finish times to do not precede start times of activities, other automatic data checks could be incorporated to reduce unrealistic data. For example, checks may be put in pace to ask participants to check data inputted if total minutes of moderate to vigorous physical activity exceeds 480 minutes; physical activity times overlap; total physical activity exceeds 1440 minutes; no drinks are entered with eating occasion; there are large periods of time where no foods/drinks or activities entered; and energy intake is much higher or lower than estimated energy requirements. These are just some examples and a number of further options can be explored.

Additional modules

The type of information required, in addition to measures of dietary and physical activity behaviour, is specific to the requirements of the study. SNAPA™ does not collect personal or demographic data from users, as it was developed for a study where this information was collected separately; however this may be a useful additional function. SNAPA™ does collect some additional data on other lifestyle behaviours, such as drinking, smoking and salt intake, and this could be expanded and adapted according to the study requirements. It would also be useful to program SNAPA™ so that some questions are only asked the first time a user completes the program. During the primary method comparison study, participants were asked to only complete the additional question section once, and to ignore these questions in subsequent completions, as the answers to these questions were unlikely to change significantly on a day to day basis. Smarter programming would eliminate the need for this additional instruction and potential confusion.

Improved researcher control

Although SNAPA™ was developed so that components could be easily edited; this still required some degree of computer literacy and training. Unfortunately for this work, although I did receive some training, in practice I found the process complicated and beyond my capabilities (despite being reasonably IT literate). Therefore, I relied heavily on the computer programmers for any changes that need to be made (no matter how small). More, and simpler, control processes for researchers will be a priority in further development work, to allow researchers to edit, add or remove questions to suit the study needs. The ability to select analysis options and even add or remove whole sections or modules (as described above) would also be useful. However, control over the main section of SNAPA™ (the diet and physical activity recall) would remain limited so that the features incorporated in this process, to aid recall, are not compromised.

Neutral design

Various designs (site graphics and styles) have been used in SNAPA™, with each incorporating a specific campaign or study colour scheme and logo. Although SNAPA™ was designed so that graphics and styles could be changed with relative ease, some computer literacy and programming knowledge is required. To allow more widespread use of the program, without the need of any re-design and associated costs (financial and time), a stand-alone, neutral program design is required.

Save-as-use capacity

Another weakness of SNAPA™ is that it requires completion in one sitting. If the user exits the program without submitting their data, these data is lost. Although this represents the usual administration of a 24 hour recall and may have additional benefits in terms of cognitive processes involved in the recall if all events/items are recorded together, in a free living situation events will occur that are beyond the researcher's control and that may prevent the user completing the program. The facility to save information already entered will reduce the burden and frustration involved in re-entering this information at a later time, potentially resulting in higher compliance and more complete datasets.

Reporting occupational activities

Recalling and quantifying occupational activity (along with lifestyle activities) can be challenging as a number of activities will be carried out day-to-day without the participant paying much attention. It was also apparent in the evaluation work that participants found describing these behaviours difficult as their working days consisted of sporadic activity. There is no easy solution for accurate reporting of this type of activity, therefore further exploratory work will investigate different approaches that can be applied in SNAPA™.

Optional audio instructions

Although not particularly identified as an issue in the current exploratory work carried out, literacy issues will affect some users' ability to complete SNAPA™ as it has text heavy instructions. The addition of audio instructions will help to overcome this issue. Audio instructions have been used successfully in existing programs (Ridley *et al.*, 2001; Subar *et al.*, 2009; Zoellner *et al.*, 2005).

Additional computer programming support

The biggest difficulty affecting the work described in this thesis was the limited (and sometimes erratic) IT and computer programming support available. A computer programmer was employed on a part-time basis at 0.2FTE (one day a week); however, their role also included the computer programming and support required by the 'Get a Better Life' campaign. Also, in practice, the computer programming needs of the development and maintenance of SNAPA™ and that required for 'Get a Better Life', were sporadic with large amounts of work required at some stages, and less at others. Quantifying the work to one day a week was sometimes very difficult. The support provided in this work was insufficient for its requirements, and this will be taken into consideration when planning future work with SNAPA™.

7.3 Further research questions

A great deal has been learned through this thesis work and a number of questions have been addressed. In turn, however, a number of interesting questions and unknowns have also emerged, and exploring these may enable further progression in this field. There are also other aspects of reliability and validity that need to be investigated in tools of this nature, in particular an exploration of longer-term reliability and ability to detect changes in behaviour over time as discussed in chapter 5.

Future work using SNAPA™ is planned that involves developing the program to incorporate the features described above, and bringing it up to date with current internet technologies. This work will also include evaluation of the revised version of the program consisting of:

- an in-depth usability testing, in a variety of settings and administration modes, with multiple rounds of testing;
- a method comparison study using direct dietary observation and combined heart rate and accelerometry as criterion methods, over multiple days;
- a short and long-term test-retest reliability (to inform ability to detect change over time);

Work involving larger samples is to be carried out so as to allow for an exploration of the performance of SNAPA™ in specific sub-groups.

Some research questions/aims that may also be included in future evaluations of SNAPA™ are:

- Explore ability of SNAPA to measure other dietary variables of interest in public health, for example wholegrain/fibre and specific fruits/vegetables;
- Explore the use of SNAPA with the incorporation of other methods, for example photography and accelerometry;

- Explore the affect of asking users to recall dietary behaviour before physical behaviour, compared with the reverse, on accuracy of recall;
- Explore the accuracy of multiple behaviour recall compared with single behaviour recall;
- Explore the accuracy and feasibility of use in specific subgroups of population (for example, pregnant women)
- Explore the accuracy of data reported using a fixed-options, compared with the ability to enter ‘other’ items.

7.4 Limitations

Throughout this thesis the limitations associated with self-reported and computerised methods have been discussed. Despite sound theoretical underpinning and learning from previous work, there will always be limitations involved in using SNAPA™ and similar methods. SNAPA™ will always be a recall method and will always be prone to the errors associated with this. Fundamentally, SNAPA™ is designed to provide relatively broad measures of behaviour, therefore, may not be suitable for all study protocols requiring more detail (for example, micronutrients or total energy expenditure).

Possibly one of the main criticisms of SNAPA™, and how it differs from computerised dietary assessment programs, is its simplistic portion size estimation method. As discussed in chapter one of this thesis, although sophisticated methods to assist portion size estimation may be useful, it is still unclear how useful these aids are (Cypel *et al.*, 1997; Frobisher and Maxwell, 2003; Godwin *et al.*, 2006; Godwin *et al.*, 2004; Haraldsdóttir *et al.*, 1994; Kuehneman *et al.*, 1994; Noethlings *et al.*, 2003; Paiva *et al.*, 2004; Tjønneland *et al.*, 1992; Turconi *et al.*, 2005). Results from this current work suggest that asking user’s to estimate portion sizes does not increase the accuracy of SNAPA™; however this needs to be explored further.

Another limitation of the design and overall aim of SNAPA™ is its close-ended nature, i.e. users can only choose from a predefined list of food items and activities. As already discussed, this will have an effect on the accuracy of the data (although to what extent is unknown) and it did cause some frustration for a number of participants. However, SNAPA™ is designed to reduce researcher (as well as participant) burden by eliminating the need for additional coding and assignment of nutrient values for 'other' items reported, which can take a significant amount of staff time. In order to reduce participant frustration, the inclusion of free-text boxes where more details could be added may be useful. On the other hand, this may increase completion time and it is unlikely that this data would be used (and therefore it may be considered unethical to collect it). A free text box at the end of the program where users can leave comments/suggestions for improvement, including suggestions for additional food items, may be useful for continued improvement. As 'free text' boxes were suggested by a number of participants, it is a clear that participants had no understanding of why they were not used. Providing optional extra information, such as a 'frequently asked questions' section that could be accessed if desired, may be a useful way to explain some of the reasons for certain design aspects of SNAPA™ for those who are interested. Understanding the reasoning may reduce frustration for some.

The use of technology and the internet will always bring in another dimension and potential source of problems that can lead to non-completion, for example actual access to internet and connection availability/problems. For part of this work, this issue was overcome by using SNAPA™ on a local server on portable laptops. This is a useful method for small studies where data collection sessions are held face-to-face with participants, but would not be suitable for large surveys. Appropriate support and training may also required for some researchers around the use of technology.

Although the theory behind an internet-based program is that it will reach large numbers of people, over a short space of time, relatively cheaply, as discussed in chapter one, using the internet does not always result in increased participation/retention. As discussed in chapters one and five, there is some evidence to suggest that internet based studies are prone to high dropout rates (Anhøj and Jensen, 2004; Birnbaum, 2004; Eysenbach, 2005; Verheijden *et al.*, 2007). The use of technology may not be suitable for all, as there remains a proportion of the population who do not use, and do not intend to use computers (with or without the internet). However, these individuals now appear to represent a diminishing proportion of the population while computer and internet use continues to increase and become part of everyday life for most people. Although internet based methods are possibly not accepted by everyone yet, as each generation passes, and the younger generation who use computers/internet as a matter of course become adults, these methods will become more and more accepted. Work with adolescents (the next generation of adults) has found that this group prefer assessment methods that incorporate new technology compared with more traditional methods (Boushey *et al.*, 2009).

When using an internet-based program, there is also the possibility of missing other groups, such as low socioeconomic status and low education, because of the current digital divides. However, these divides are continually narrowing. Although, SNAPA™ is not designed for use in other countries, programs of this kind will not be suitable in countries where internet use is low.

7.5 Overall conclusion/summary

The Synchronised Nutrition and Activity Program for Adults is a promising tool for the surveillance of diet and physical behaviours at a group level in adult populations at one time point; however, at this stage the tool appears less accurate for physical activity behaviours than for diet and further development is needed to eliminate the biases observed. The tool is currently relatively imprecise at the individual level and its ability to detect change over time is unknown. Further development and evaluation work is now required to address current usability issues; bring the program up-to-date with latest internet technologies; for continuous improvement in terms of accuracy, reliability and feasibility at a group level; and to assess the ability of the tool to detect changes over time.

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THE DEVELOPMENT AND EVALUATION OF A NOVEL ONLINE TOOL FOR ASSESSING DIETARY INTAKE AND PHYSICAL ACTIVITY LEVELS FOR USE IN ADULT POPULATIONS

VOLUME 2 (of 2)

FRANCES CAROLINE HILLIER

Thesis submitted for
the degree of Doctor of Philosophy

School of Medicine and Health
Durham University

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List of Appendices

Preliminary appendices

Chapter appendices

Appendix p1 Conference proceedings for the 16th European Conference on Obesity (ECO), 2008

T5:OS2.3

Concurrent validity of a novel online tool for public health surveillance of dietary and physical activity behaviours in adults

Hillier, F.C[1], Batterham, A.M[1], Crooks, S[1], Summerbell, C.D[1]

[1]University of Teesside, Middlesbrough, UK

Introduction: Computer-based tools may provide standardised, cost-effective and convenient alternatives to current standard methods of dietary and physical activity assessment. The Synchronised Nutrition and Activity Program for Adults (SNAPA) assesses previous day dietary and physical activity behaviours in adult populations. The aim of this study was to evaluate the concurrent validity of SNAPA data against multiple pass recall (MPR) dietary interview [1] and accelerometry data.
Methods: Seventy-one adults (mean age 43.0 years ±16.3) were asked to wear an accelerometer (Actigraph GT1M, Fort Walton Beach, FL, USA) during waking hours over a 24-hour period. The following day participants completed SNAPA and a 24-hour MPR interview. Percentage of energy from fat; number of portions of fruits and vegetables; and number of minutes of moderate to vigorous physical activity (MVPA; cut-point 2020 cpm) was calculated from data collected by SNAPA, MPR interviews and accelerometry for the same 24-hour period.
Results: Correlations between SNAPA and MPR-derived percentage of energy from fat and portions of fruit and vegetables were 0.39 (Bootstrapped 90% CI, 0.21 to 0.56) and 0.40 (Bootstrapped 90% CI, 0.21 to 0.58), respectively. The correlation between SNAPA and accelerometry-derived MVPA was 0.39 (Bootstrapped 90% CI, 0.08 to 0.64).
Conclusion: The correlations observed indicate acceptable concurrent validity and are comparable with those observed typically for behavioural self-report tools of this type. SNAPA is a suitable method for group-level assessment of dietary and physical activity behaviours in adult populations.

1. Moshfegh A et al. *FASEB Journal.* 1999;13:A603.

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Appendix p2 Conference proceedings of the Nutrition Society Summer Conference, 2008

Proceedings of the Nutrition Society (2008), **67** (**OCE8**), E370 doi:10.1017/S002966510800044X

Summer Meeting 30 June–3 July 2008

A novel online tool for capturing dietary and physical activity behaviours in adults: concurrent validity against standard reference methods

Frances Hillier, Alan Batterham, Sean Crooks and Carolyn Summerbell
University of Teesside, Middlesbrough, UK

Computer and online tools are a promising alternative to current standard methods for the assessment of dietary and physical activity behaviours in populations. The synchronised nutrition and activity program for adults (SNAPA) collects data on previous-day dietary and physical activity behaviours in adult populations. The aim of the present study was to evaluate the concurrent validity of SNAPA data against multiple-pass-recall (MPR) dietary interview and accelerometry data and, in addition, investigate the influence on the concurrent validity of using estimated portion sizes (EPS) *v.* average portion sizes (APS)[1] during analysis of the SNAPA diet data.

Seventy-one adults (mean age 43.0 (SD 16.3) years) wore an accelerometer (Actigraph GT1M; Actigraph, Fort Walton Beach, FL, USA) during waking hours over a 24 h period. The following day participants completed SNAPA and a 24 h MPR interview. Percentage energy from fat; number of portions of fruit and vegetables; (F/V) and time spent (min) in moderate to vigorous physical activity (MVPA; accelerometry cut-point 2020 counts per min and estimated energy expenditure of ≥ 3 metabolic equivalents (METS)) was calculated from data collected by SNAPA, MPR interviews and accelerometry for the same 24 h period.

	SNAPA (EPS)		SNAPA (APS)		Reference method	
	Mean	SD	Mean	SD	Mean	SD
Percentage energy from fat	30.5	9.7	32.3	9.8	34.0	8.9
No. of F/V portions	3.3	2.9	3.3	2.9	4.9	3.8
Minimum MVPA	43.3	64.6	–	–	42.3	36.3

Correlations between SNAPA and MPR-derived percentage energy from fat were 0.46 (bootstrapped 90 % CI 0.30, 0.60) using EPS and 0.48 (bootstrapped 90% CI 0.31, 0.64) using APS. The correlation between methods for portions of F/V was 0.42 (bootstrapped 90 % CI 0.22, 0.60) regardless of the portion size used during analysis. The correlation between SNAPA and accelerometry-derived MVPA was 0.39 (bootstrapped 90 % CI 0.08, 0.64).

The results indicate reasonable concurrent validity of SNAPA *v.* the standard reference methods and suggest that the tool is suitable for the surveillance of dietary and physical activity behaviours in groups or populations. The use of EPS did not improve the concurrent validity of SNAPA for dietary behaviours compared with data collected by MPR interviews.

This study is part of a larger project commissioned by the Food Standards Agency.

1. Wrieden WL & Barton KL (2006) *Calculation and Collation of Typical Food Portion Sizes for Adults Aged 19–64 and Older People Aged 65 and Over. Final Technical Report to the Food Standards Agency* (*Project N08026*); available from Food Standards Agency Information Centre.

Appendix p3 Conference proceedings of the 17th European Conference on Obesity (ECO), 2009

T1:PO.54

"Get a Better Life": A social marketing campaign to encourage adults to make healthful changes to their eating and physical activity behaviours

Pedley, C.L.[1]; Hillier, F.C.[1]; Batterham, A.M.[2]; Crayton, A.M.[1]; Nixon, C.A.[1]; Summerbell, C.D.[1]

[1]Durham University, Stockton-on-Tees, UK
[2]University of Teesside, Middlesbrough, UK

"Get a Better Life" is a social marketing campaign which targets adults living in the Tees Valley region of the North East of England. Support for the campaign is provided by the local media, who provide regular stories and articles assisting with the engagement and retainment of the target population. Participants are asked to make two pledges related to improving their diet and physical activity levels, and work towards these pledges for one year with online data collected at baseline, 6-months and 12-months. Ongoing support is provided through a campaign website and all participants receive a support pack containing campaign-branded merchandise once signed up. Participants who complete the campaign are eligible to win prizes donated by local businesses.

The campaign was launched between January and April 2008 with a total of 1073 adults signing up online (mean age = 40.2±13 years, 70% female). The website was visited on average 1509 times per month during this period (averaging 57 visits per day). 16.7% of participants reported being unemployed which is reflective of the low socio-economic status reported in this region. Self-reported height and weight were used to calculate BMI with 29.1% overweight, 26.1% obese and 6% very obese. General health and fitness related reasons were most frequently given for participation in the campaign (72.2%), with weight related reasons the next frequent (44.6%).

The campaign will continue until the end of April 2009 and will be evaluated using baseline and follow-up data collected at 6 and 12 months.

Conflict of Interest: None. *Funding:* Research relating to this abstract was commissioned by the Food Standards Agency.

T1:PO.55

Efficacy of Protein-Rich Oriental Diet (PRO-Diet) in a community-based obesity control program for obese Koreans

Joo, N.S.[*]; Park, J.W.[†]; Park, G.H.[‡]; Chang, H.M.[‡]; Kim, C.W.[*]; Kim, B.T.[§]

[*]Department of Family Practice and Community Health, Ajou University School of Medicine, Suwon, Korea,
[†]Dr. Park's Reset Clinic, Seoul, Korea,
[‡]Department of Family Medicine, Hallym University, Anyang, Korea,
[§]Corresponding Author Bom-Taeck Kim,
Address: Department of Family Practice and Community Health, Ajou University School of Medicine

Background and Objective; The Protein-rich Oriental Diet (PRO Diet) is a modified protein-enriched diet program that encourages the consumption of low-saturated fat, high protein Oriental type foods (legumes, soybean curd, soy milk, mushrooms, nuts, seafood, fish, chicken breast, and lean meat) and vegetables while avoiding foods that contain simple sugars and refined starches and high in saturated fats. We evaluated the effects of PRO Diet when applying a 12- week community-based obesity control program.

Methods; A total of 515 subjects (55 men, 460 women, mean age 41.9±9.8, BMI 28.0±3.3kg/m^2) participated in the program offered at two Public Health Centers. PRO Diet was applied as a main diet program for 12 weeks. Participants were educated and advised weekly or bi-weekly by trained nurses and dietitians. Short Message Services via mobile phones were also utilized to help with behavior modification of the participants.

Results; One hundred seventy-eight subjects (34.6%) completed the 12-week PRO-Diet program. In a per protocol (PP) analysis, the mean changes in body weight and waist circumference were -4.71±2.55kg (p<.001) and -6.73±3.05cm (p<.001), respectively. Triglyceride (-30.16±59.46mg/dl, p<.001) levels after 12 weeks were significantly lower than at baseline. There were no reports of serious adverse events throughout the program, and the overall satisfaction index of the diet program was high.

Conclusion; PRO Diet was effective and well-tolerated for controlling weight in a community-based weight control program. Further evaluation for long-term effects are needed..

Key words; Protein Rich Oriental Diet, community-based obesity program, Korea

T1:PO.56

Diet and physical activity behaviours assessed by a novel online data collection tool in the "Get a Better Life" study

Hillier, F.C.[1]; Batterham, A.M.[2]; Pedley, C.L.[1]; Crayton, A.M.[1]; Nixon, C.A.[1]; Crooks, S.[2]; Summerbell, C.D.[1]

[1]Durham University, Stockton-on-Tees, UK
[2]University of Teesside, Middlesbrough, UK

The "Get a Better Life" campaign aims to encourage healthy eating and increase physical activity levels of adults living in the Tees Valley in the North East of England, an area of high deprivation and poor health status. A total of 1073 adults (mean age = 40.2±13.0 years; 70% female) signed up to the campaign between January and April 2008.

Baseline previous day diet and physical activity behaviour data were collected using the novel online tool: the Synchronised Nutrition and Activity Program for Adults (SNAPA)[1]. Mean (SD) percentage food energy from fat was 31.7 (12.6) and 34.7 (9.3) after excluding under reporters (n=547). The median (range) number of fruit and vegetable portions was 1 (0-16) and, excluding under reporters, 2 (0-16) portions. The most frequently reported food items by participants were tea (40%), sandwich (29%) and coffee (27%). The percentage of participants who carried out ≥30 minutes of moderate-vigorous activity (MVPA) was 20%. The most frequently reported activities were walking (47%), housework (44%) and the sedentary behaviour of watching TV/DVD (19%).

Baseline diet outcomes were similar to national averages after the exclusion of under reporters. Compared to national survey data (34% of all adults carrying out ≥30 minutes MVPA at least 5 days per week) physical activity levels in the current study appeared to be low. Participants will complete SNAPA again at 6 and 12 months, and the data collected used to evaluate the "Get a Better Life" campaign. (Hillier et al. (2008) Int J Obes **32** (S1):S32)

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T1:PO.57

The effect of resistance exercise training on body composition and strength in obese prepubertal children

Alberga, A.[1]; Lafleche, A.[2]; Farnesi, C.[3]; Boucher, B.[2]; Legault, L.[4,5]; Komorowski, J.[1]

[1]University of Ottawa, Ottawa, Canada
[2]Concordia University, Montreal, Canada
[3]University of Alberta, Montreal, Canada
[4]McGill University, Montreal, Canada
[5]Montreal Children's Hospital, Montreal, Canada

Introduction: The objective of this study was to assess the effect of resistance training on body composition and strength in obese children.

Methods: Participants 8-12 y of age, Tanner Stage 1, BMI ≥95th percentile for age and sex, were randomized to either the moderate intensity, high repetition resistance training (E = 12) or the non-intervention control group (C = 8) for 12 weeks. Exercise training was performed twice a week for 75 minutes/ session. Body composition was assessed using DXA and strength was evaluated using a 1RM test. All measures were performed at baseline and after 12 weeks.

Results: After 12 weeks, there was no change in percent body fat and fat mass index [FM/height^2 (kg/m^2)] in any of the groups. The exercise group showed a significant increase in weight (57.5 ± 13.5 vs. 59.5 ± 14.1 kg),

Appendix p4 Conference proceedings of the Annual Conference of the International Society of Behavioural Nutrition and Physical Activity, 2009

P1 T4.20

Online vs face-to-face recruitment of participants in the Get a Better Life study: a social marketing campaign to encourage healthy eating and increase physical activity levels in adults

F. Hillier, A. Batterham, C. Pedley, A. Crayton, C. Nixon and C. Summerbell

Purpose: The aim of this study is to compare baseline characteristics of participants who signed up to the 'online' arm of the Get a Better Life campaign with those who signed up to the 'community' arm, and to investigate rudimentarily the costs associated with each method. **Methods:** Volunteer recruitment took place between January and October 2008, either via the campaign website (no face-to-face contact) or face-to-face with a trained 'Lifestyle Helper'. For the purpose of this study we performed cross-sectional comparative analysis of baseline data. **Results:** A total of 1073 participants were recruited online and 128 face-to-face. The only statistically significant differences between the online and face-to-face samples were for age (40.2 vs 43.8 years, respectively, $p=0.02$) and the proportion of participants who were homemakers or retired (11.2% vs 23.2%, $p=0.002$). Full-time employment and unemployment rates, ethnicity, and gender were similar for both groups, as was education level (measured as % participants with A/AS-level qualification or higher). The cost (excluding staff costs) of online recruitment was approximately £13 per participant compared with approximately £28 per participant for face-to-face recruitment. More staff time was required in the community arm for training, promotion and data collection; however, additional IT support was required for the online arm. **Conclusions:** There were no practically significant differences between the groups suggesting that no substantial sampling bias occurred between the recruitment methods. Online methods appear to be cost-effective for engagement and recruitment: however, follow-up data is required to investigate the effectiveness of each method for retention of participants.

Funding Source: Food Standards Agency, UK

P1 T4.21

Health belief model predictors of calcium consumption and physical activity in college women

K. Gammage, L. Lamarche, D. Mack and P. Klentrou

Purpose: The purpose of the present study was to examine if the Health Belief Model could predict osteoporosis-prevention behaviours (specifically calcium consumption and physical activity) in female college women. **Methods:** A total of 100 female college-aged women (Mage = 20.6 years, SD = 1.55) completed a series of questionnaires assessing health beliefs (perceived susceptibility to and severity of osteoporosis, calcium barriers and benefits, exercise barriers and benefits, general health motivation, calcium self-efficacy, exercise self-efficacy, and osteoporosis knowledge). In addition, self-reported weekly physical activity and daily calcium consumption were also assessed. **Results/Findings:** Two regressions were conducted, predicting physical activity and calcium consumption from the health belief model variables, after controlling for age and percent body fat. For physical activity, the final model was significant ($F(12, 86) = 4.20$, $p<.001$), accounting for approximately 28% of the variance in physical activity behaviour. Age, exercise benefits, and general health motivation were the only significant predictors (all ps<.05). For calcium consumption, the final model was again significant ($F(12, 86)=2.59$, $p<.01$), accounting for approximately 16% of the variance in calcium consumption. Calcium barriers ($p<.05$) was the only significant predictor of calcium consumption, with higher perceived barriers associated with lower calcium consumption. **Conclusions:** These results suggest that in young women, the health belief model can predict osteoporosis-preventive behaviours. However, the perceived efficacy of the preventive behaviours, rather than perceived threat of osteoporosis, may be more closely related to physical activity and calcium consumption.

Funding Source: Social Sciences and Humanities Research Council of Canada

Appendix p5 Conference proceedings of the Annual Conference of the International Society of Behavioural Nutrition and Physical Activity, 2010

P037

How many days of monitoring predict physical activity and sedentary behavior in older adults?

Authors:

Teresa Hart, Scott Strath, Ann Swartz, Susan Cashin

Purpose: To establish the number of days of pedometer, accelerometer, and physical activity (PA) log monitoring are needed to predict average PA and sedentary behavior levels in older adults.

Methods: Fifty-four older men and women (Mean age = 69 ± 7 years, range = 55-86 years; mean BMI = 27.5 ± 4.7kg/m2) wore a Yamax Digiwalker SW 200 pedometer and an ActiGraph 7164 accelerometer concurrently while completing a PA log for 21 consecutive days (mean wear/completion time = 823.1 ± 103.3 min/day). Spearman-Brown Prophecy Formulas based on Intraclass Correlations for all 21 days and a reliability of .80 were used to predict the number of days of wear/completion needed to represent total PA (pedometer steps, total accelerometer counts, and total PA log MET-min/day) and sedentary behavior (total minutes from accelerometer with ≤50 activity counts/min).

Results: Four days of monitoring from a pedometer and PA log was deemed necessary and 3 days from an accelerometer to reliably predict total PA behavior. Eight days of monitoring was necessary to reliably predict sedentary behavior using an accelerometer.

Conclusions: Depending on the behavior of interest, these results suggest the number of days of monitoring needed to determine typical PA or sedentary behavior in older adults. The number of days to determine PA was consistent across both objective (pedometer and accelerometer) and subjective (PA log) instruments. However, more days were needed to determine typical sedentary behavior in this population.

P038

Objectively-measured physical activity in adults in North East England: Prevalence depends critically on measurement method

Authors:

Frances Hillier, Alan Batterham, Carolyn Summerbell

Purpose: To investigate physical activity levels of free-living adults in North East England using two objective methods of measurement.

Methods: Physical activity levels of 75 adults (mean age 34.6, SD ±11.2 years) were measured over 7 consecutive days using waist-mounted accelerometry (GT3X [uniaxial mode], Actigraph, Pensacola, FL, USA), and synchronised heart rate and accelerometry (Actiheart, CamNtech, Cambridge, UK). Minutes per day of moderate to vigorous physical activity (MVPA; estimated energy expenditure of ≥3 METs, accelerometry cut-point 2020 counts·min-1) and vigorous physical activity (VPA; ≥6 METs, accelerometry cut-point 5999 counts·min-1) were calculated for each method.

Results:

	GT3X		Actiheart	
	Mean	**(SD)**	**Mean**	**(SD)**
Minutes MVPA day-1	34.7	(59.7)	97.3	(25.1)
Minutes MVPA day-1 (accumulated in bouts ≥10 minutes)	10.8	(5.0)	35.3	(33.2)
Minutes VPA day-1	2.9	(5.3)	11.8	(14.0)

Only one participant (1.4%) achieved the recommended level of physical activity1 based on the accelerometry data. Via synchronised heart rate and accelerometry, however, the sample point prevalence was 20% (31.0% in men, n=9 and 12.2% in women, n=5). The between-method difference in prevalence was 18.6% (95% CI, 9 to 29%, P=0.0002).

Conclusions: The remarkably low prevalence of accelerometry-determined physical activity reflects recent survey findings using identical methods2. However, accelerometry fails to capture the totality of physical activity energy expenditure and prevalence estimates are influenced markedly by choice of count cut-point. We conclude that physical activity prevalence may be grossly underestimated by accelerometry alone.

Department of Health (2004). At least five a week. NHS Information Centre (2009). Health Survey for England 2008.

P039

How much is enough: Do serving sizes for children meet their nutrient needs?

Authors:

Samantha Ramsay, Laurel Branen, Susan Johnson

Purpose: To determine whether serving size recommendations for young children meet dietary standards for nutrient adequacy.

Methods: We examined 3 recommendations for children's serving sizes (1T per year of age [T/y], MyPyramid and Child and Adult Care Food Program [CACFP]) to determine whether they meet the Estimated Average Requirements (EAR) for children ages 2-5y. Fourteen days of menus (3 meals and 2 snacks/day) were constructed by randomly selecting meals and snacks from 72 CACFP approved menus. Menus were analyzed and mean daily nutrient contents were calculated. Nutrient contents were compared to EARs for male and female children 2 – 5y and ANOVA and Kruskal-Wallis tests were used to compare the 3 approaches.

Results: Nutrient requirements were met for most nutrients by all approaches. However, EARs for fat, vitamin E, chromium, and potassium were not met by any approach in any year or for both sexes. In contrast, protein and carbohydrate contents were well over the EAR for all approaches. The T/y resulted in energy contents below the EAR for each year of age and for both sexes (range 72-90% EAR). For age 2y, the T/y was lower in carbohydrate and fiber ($p < .001$) for both sexes. For ages 3-4y, T/y had lower energy, protein, carbohydrate and fiber ($p < .05$),and for age 5y protein was lower ($p < .001$) for T/y.

Appendix p6 Conference proceedings of the 11th International Conference on Obesity (ICO), 2010

T4:PO.334

The Synchronised Nutrition and Activity Program for Adults (SNAPA™): Accuracy against direct diet observation and synchronised heart rate and accelerometry

Hillier FC[1], Summerbell CD[1] and Batterham AM[2]
[1]*Durham University, Stockton-on-Tees, UK;* [2]*Teesside University, Middlesbrough, UK*

Introduction: We have reported reasonable group-level accuracy for the Synchronised Nutrition and Activity Program for Adults (SNAP-A™; a previous-day recall tool) against reference measures of multiple pass recall dietary interview and accelerometry[1]. The aim of this study was to compare SNAPA™ against more precise reference methods over multiple days.
Methods: Participants (aged ≥16 years) wore a synchronised heart rate and accelerometer device (Actiheart®, CamNtech, Cambridge, UK) for seven days, were observed directly during four lunchtimes, and completed SNAPA™ on five days. Agreement between observation and SNAPA™ was assessed via match rate ([number foods correctly recalled/number foods observed] × 100) and number of phantoms (foods recalled but not observed). Mean minutes per day of moderate to vigorous physical activity (MVPA; estimated energy expenditure of ≥3 METs) was estimated from SNAPA and Actiheart® data, with bias evaluated using Passing-Bablok regression (Type II regression).
Results: Sixty-four participants provided Actiheart® and SNAPA™ data, with complete diet observation data obtained for $n = 46$. The mean (SD) match rate and number of phantoms was 83.0% (23.3%) and 0.13 (0.24), respectively. The median (interquartile range) MVPA from SNAPA™ was 48 (19 to 72) minutes vs. 81 (60 to 118) minutes for Actiheart®. For MVPA there was a fixed bias (intercept) of -31 minutes (90% confidence interval -64 to -16 minutes) but no marked proportional bias.
Conclusion: Agreement between SNAPA™ and lunchtime observation was good. However, SNAPA underestimated total MVPA substantially, possibly due to more limited recall of shorter bouts of activity.
Reference: 1. Hillier *et al.* (2008) *IJO* 32 (S1):S32.

T4:PO.335

Regression of metabolic syndrome in severe obesity

Gentile MG[1], Corradi E[1] and Oltolini A[1]
[1]*Clinical Nutrition Department, Niguarda Hospital, Milan, Italy*

Introduction: The metabolic syndrome (MetS) is characterized by abdominal obesity, insulin resistance, dyslipidemia and hypertension. Obesity is assumed to play an important role in the development of MetS.
The aim of the study was to evaluate the efficacy of an integrated but personalized intervention which includes: nutritional therapy, psychological therapy and proactive physical activity.
Patients and Methods: We evaluated retrospectively 52 patients (24 males) with a baseline (t0 time) BMI >40 kg/m^2 and who afterwards (time T1 = 460 ± 243 days) succeeded in losing more than 20% of their initial body weight.
Results: The mean values of some clinical and pathology variables taken at the times T0 and T1 are shown:

	T0	T1
Patients No.	52	52
Weight (kg)	146,43 ± 21,07	105,06 ± 18,54*
BMI (kg/m^2)	51.84 ± 7,50	37,14 ± 6,73*
Waist (cm)	135,28 ± 14,27	109,63 ± 12,93*
Systolic blood pressure (mmHg)	146,57 ± 20,81	124,30 ± 14,35*
Diastolic blood pressure (mmHg)	89,56 ± 9,23	75,82 ± 7,86*
Plasma HDL cholesterol (mg/dl)	43,05 ± 9,69	44,66 ± 13,42**
Plasma Triglycerides (mg/dl)	148,40 ± 74,10	97,72 ± 35,54*
Glycemia (mg/dl)	105,25 ± 25,54	86,04 ± 9,20*
Measured Basal Metabolic Rate (kcal/24h)	2307,74 ± 420,94	1816,37 ± 266,31*

*$P < 0.0001$
**not significant

At the time T1 only 6 pts were still suffering from "full" MetS. In addition to a substantial reduction of the blood pressure and the glycemia (both mean values and variances) 15pts had a reduction of their antihypertensive drugs, 3 a reduction of oral antidiabetics, while 2 needed a more aggressive drug treatment for hypertension and 1 started on with statin for dyslipidemia.
Conclusion: The results show how an integrated therapy causes a significant weight loss, likely also improved nutritional, metabolic parameters and blood pressure and may lead to an improvement of MetS.

Conflict of interest: None disclosed.
Funding: No funding.

T4:PO.336

Self-monitoring and weight loss: adherence matters for users of a web-based food and exercise diary

Johnson F[1] and Wardle J[1]
[1]*Cancer Research UK Health Behaviour Research Centre, Department of Epidemiology and Public Health, University College London, UK*

Introduction: Self-monitoring of food intake or other target behaviors is proving to be an effective motivational tool for dietary change and weight control.
Methods: The mechanisms through which self monitoring may be effective are discussed with reference to the weight change of 3623 subscribers to a commercial, internet weight-control programme based on dietary intake and exercise diaries.
Results: Among these programme participants, frequency of recording food intake and exercise was strongly associated with weight loss after controlling for age, sex and length of time using the program. The effectiveness of diary adherence interacted with weight status, showing that compliance with dietary diaries was a stronger predictor of weight loss for those at the upper end of the BMI spectrum, than for those of normal weight. Self monitoring of exercise was more closely associated with weight loss among men than women.
Conclusion: Frequent monitoring of target behaviors using daily diaries may facilitate weight loss by enhancing the attentional focus of users on their behavioural objectives. It may also assist with habit formation. In the context of debate about the risks and benefits of individual weight control, a more focused attention on the mechanisms and effects of behavioural self-monitoring is timely.
Conflict of interest: None disclosed.
Funding: Jane Wardle and Fiona Johnson are supported by Cancer Research UK.

T4:PO.337

Associations between adolescents' physical activity and obesogenic health behaviours

Hardy LL[1], Grunseit A[1], King L[1], Flood V[2], Wolfenden L[3] and Milat A[4]
[1]*Physical Activity, Nutrition and Obesity Research Group (PANORG) The University of Sydney, Sydney, NSW Australia;* [2]*Cluster of Public Health Nutrition, Institute of Obesity, Nutrition and Exercise, The University of Sydney, NSW Australia;* [3]*NSW Cancer Institute, Newcastle University, NSW Australia;* [4]*NSW Department of Health, Sydney NSW Australia*

Introduction: Low physical activity (PA) potentially contributes to the development of excess weight. Given PA markedly declines dur-

Appendix A Food item list

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
99	Alco pop	Regular	NA	17-175
99	Alco pop	Regular	NA	17-175
99	Alco pop	Diet	NA	17-505
99	Alco pop	Diet	NA	17-505
1	Bacon	Regular	NA	19-003
1	Bacon	Reduced fat	NA	19-008
2	Bagel	NA	NA	11-534
3	Baked beans	Regular	NA	50-694
3	Baked beans	Regular	NA	50-694
3	Baked beans	Regular	NA	50-694
3	Baked beans	Low salt and sugar	NA	50-695
3	Baked beans	Low salt and sugar	NA	50-695
3	Baked beans	Low salt and sugar	NA	50-695
115	BBQ sauce	Standard	NA	17-513
115	BBQ sauce	Standard	NA	17-513
4	Beef	Standard	Y	18-473
4	Beef	Standard	Y	18-473
4	Beef	Standard	Y	18-473
4	Beef	Standard	Y	18-473
4	Beef	Standard	Y	18-473
4	Beef	Standard	N	18-474
4	Beef	Standard	N	18-474
4	Beef	Standard	N	18-474
4	Beef	Standard	N	18-474
4	Beef	Standard	N	18-474
7	Beer	Standard	NA	17-506
7	Beer	Standard	NA	17-506
7	Beer	Standard	NA	17-506
7	Beer	Standard	NA	17-506
8	Biscuits	Savoury (for cheese)	NA	11-510
8	Biscuits	Chocolate	NA	11-512
8	Biscuits	Plain	NA	11-513
9	Bread roll	Granary, with butter/margarine	NA	00-103
9	Bread roll	White, with butter/margarine	NA	00-104
9	Bread roll	Wholemeal, with butter/margarine	NA	00-105
9	Bread roll	Granary, with reduced fat butter/margarine	NA	00-106
9	Bread roll	White, with reduced fat butter/margarine	NA	00-107
9	Bread roll	Wholemeal, with reduced fat butter/margarine	NA	00-108
9	Bread roll	Wholemeal	NA	11-478

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
9	Bread roll	Granary	NA	11-479
9	Bread roll	White	NA	11-483
10	Bread, sliced	Granary, with butter/margarine	NA	00-091
10	Bread, sliced	White, with butter/margarine	NA	00-092
10	Bread, sliced	Wholemeal, with butter/margarine	NA	00-093
10	Bread, sliced	Granary, with butter/margarine	NA	00-094
10	Bread, sliced	White, with butter/margarine	NA	00-095
10	Bread, sliced	Wholemeal, with butter/margarine	NA	00-096
10	Bread, sliced	Granary, with reduced fat butter/margarine	NA	00-097
10	Bread, sliced	Granary, with reduced fat butter/margarine	NA	00-098
10	Bread, sliced	White, with reduced fat butter/margarine	NA	00-099
10	Bread, sliced	White, with reduced fat butter/margarine	NA	00-100
10	Bread, sliced	Wholemeal, with reduced fat butter/margarine	NA	00-101
10	Bread, sliced	Wholemeal, with reduced fat butter/margarine	NA	00-102
10	Bread, sliced	Granary	NA	11-461
10	Bread, sliced	Granary	NA	11-461
10	Bread, sliced	White	NA	11-468
10	Bread, sliced	White	NA	11-468
10	Bread, sliced	Wholemeal	NA	11-476
10	Bread, sliced	Wholemeal	NA	11-476
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-109
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-110
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-111
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-112
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-113
11	Breakfast cereal	Hi fibre (e.g. shredded	NA	00-114

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
		wheat, branflakes), with milk and sugar		
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-115
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-116
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk	NA	00-117
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk	NA	00-118
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk	NA	00-119
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk and sugar	NA	00-120
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk and sugar	NA	00-121
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk and sugar	NA	00-122
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
11	Breakfast cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), no milk	NA	11-490
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), no milk	NA	11-490
11	Breakfast cereal	Non hi fibre (e.g. cornflakes, rice krispies), no milk	NA	11-490
116	Brown sauce	Standard	NA	17-513
116	Brown sauce	Standard	NA	17-513
5	Burger (including bun)	Hamburger	NA	19-311
5	Burger (including bun)	Quarter pounder	NA	19-312
5	Burger (including bun)	Cheeseburger	NA	19-314

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
6	Burger (no bun)	Standard	NA	19-030
12	Butter	Reduced fat	NA	17-016
12	Butter	Reduced fat	NA	17-016
12	Butter	Reduced fat	NA	17-016
12	Butter	Regular	NA	17-485
12	Butter	Regular	NA	17-485
12	Butter	Regular	NA	17-485
13	Cake	Standard	NA	11-580
13	Cake	Standard	NA	11-580
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-109
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-110
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-111
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk	NA	00-112
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-113
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-114
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-115
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), with milk and sugar	NA	00-116
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk	NA	00-117
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk	NA	00-118
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk	NA	00-119
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk and sugar	NA	00-120
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk and sugar	NA	00-121

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), with milk and sugar	NA	00-122
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
108	Cereal	Hi fibre (e.g. shredded wheat, branflakes), no milk	NA	11-486
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), no milk	NA	11-490
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), no milk	NA	11-490
108	Cereal	Non hi fibre (e.g. cornflakes, rice krispies), no milk	NA	11-490
84	Cereal bar	Standard	NA	00-003
85	Chapati	Standard	Y	11-458
85	Chapati	Standard	N	11-459
14	Cheese	Regular	NA	12-346
14	Cheese	Regular	NA	12-346
14	Cheese	Regular	NA	12-346
14	Cheese	Regular	NA	12-346
14	Cheese	Reduced fat	NA	12-348
14	Cheese	Reduced fat	NA	12-348
14	Cheese	Reduced fat	NA	12-348
14	Cheese	Reduced fat	NA	12-348
107	Cheeseburger	Standard	NA	19-314
15	Chicken/turkey	Plain	NA	18-323
15	Chicken/turkey	Plain	NA	18-323
15	Chicken/turkey	Plain	NA	18-323
15	Chicken/turkey	Breadcrumb coated	NA	19-118
15	Chicken/turkey	Breadcrumb coated	NA	19-118
15	Chicken/turkey	Breadcrumb coated	NA	19-118
15	Chicken/turkey	Breadcrumb coated	NA	19-118
86	Chilli con carne	Vegetable/vegetarian	NA	15-370
86	Chilli con carne	Meat	NA	19-337
86	Chilli con carne	Meat	NA	19-337
86	Chilli con carne	Meat	NA	19-337
16	Chips	Standard	Y	50-681
16	Chips	Standard	Y	50-681
16	Chips	Standard	Y	50-681
16	Chips	Standard	N	50-687
16	Chips	Standard	N	50-687

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
16	Chips	Standard	N	50-687
17	Choc ice	Standard	NA	12-384
18	Chocolate	Standard	NA	17-089
18	Chocolate	Standard	NA	17-089
18	Chocolate	Standard	NA	17-089
18	Chocolate	Standard	NA	17-089
19	Chocolate spread	Standard	NA	17-069
19	Chocolate spread	Standard	NA	17-069
20	Chow mein	Standard	NA	19-321
21	Cider	Standard	NA	17-224
21	Cider	Standard	NA	17-224
21	Cider	Standard	NA	17-224
21	Cider	Standard	NA	17-224
22	Cocoa	Standard	NA	17-532
22	Cocoa	Standard	NA	17-532
23	Coffee	With milk and sweetner	NA	00-057
23	Coffee	With milk	NA	00-057
23	Coffee	With milk and sweetner	NA	00-057
23	Coffee	With milk	NA	00-058
23	Coffee	With milk and sugar	NA	00-075
23	Coffee	With milk and sugar	NA	00-076
23	Coffee	Without milk, with sugar	NA	00-077
23	Coffee	Without milk, with sugar	NA	00-078
23	Coffee	Without milk	NA	17-152
23	Coffee	Without milk, with sweetener	NA	17-152
23	Coffee	Without milk	NA	17-152
23	Coffee	Without milk, with sweetener	NA	17-152
118	Cottage pie	Meat with added vegetables	NA	00-016
118	Cottage pie	Vegetarian/vegetable	NA	15-313
118	Cottage pie	Meat	NA	19-216
24	Cream	Single	NA	12-332
24	Cream	Whipping	NA	12-333
24	Cream	Double	NA	12-334
24	Cream	UHT	NA	12-338
25	Crisps (any flavour)	Regular	NA	17-495
25	Crisps (any flavour)	Regular	NA	17-495
25	Crisps (any flavour)	Regular	NA	17-495
25	Crisps (any flavour)	Reduced fat	NA	17-496
25	Crisps (any flavour)	Reduced fat	NA	17-496
25	Crisps (any flavour)	Reduced fat	NA	17-496
26	Crumpet	With butter/margarine	NA	00-123
26	Crumpet	With reduced fat butter/margarine	NA	00-124
26	Crumpet	Plain	NA	11-535

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
87	Curry	Meat with added vegetables	NA	00-005
87	Curry	Meat with added vegetables	NA	00-005
87	Curry	Meat with added vegetables	NA	00-005
87	Curry	Vegetable/vegetarian	NA	00-006
87	Curry	Vegetable/vegetarian	NA	00-006
87	Curry	Vegetable/vegetarian	NA	00-006
87	Curry	Meat	NA	19-169
87	Curry	Meat	NA	19-169
87	Curry	Meat	NA	19-169
27	Eggs	Standard	Y	12-919
27	Eggs	Standard	N	50-293
28	Fish, oily	Fresh	NA	16-327
28	Fish, oily	Fresh	NA	16-327
28	Fish, oily	Fresh	NA	16-327
28	Fish, oily	Fresh	NA	16-327
29	Fish, white	Plain	NA	16-013
29	Fish, white	Plain	NA	16-013
29	Fish, white	Plain	NA	16-013
29	Fish, white	Battered	NA	16-021
29	Fish, white	Battered	NA	16-021
29	Fish, white	Battered	NA	16-021
29	Fish, white	Breadcrumb coated	NA	16-027
29	Fish, white	Breadcrumb coated	NA	16-027
29	Fish, white	Breadcrumb coated	NA	16-027
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Regular	NA	17-175
30	Fizzy drinks (any flavour)	Diet	NA	17-505
30	Fizzy drinks (any flavour)	Diet	NA	17-505
30	Fizzy drinks (any flavour)	Diet	NA	17-505
30	Fizzy drinks (any flavour)	Diet	NA	17-505
30	Fizzy drinks (any flavour)	Diet	NA	17-505
30	Fizzy drinks (any flavour)	Diet	NA	17-505
30	Fizzy drinks (any flavour)	Diet	NA	17-505
31	Fortified wine	Standard	NA	17-237
31	Fortified wine	Standard	NA	17-237
32	French bread	Standard	NA	11-471
32	French bread	Standard	NA	11-471
88	Fruit	Fresh	NA	50-856
88	Fruit	Dried	NA	50-958

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
33	Fruit juice (any flavour)	Standard	NA	14-301
33	Fruit juice (any flavour)	Standard	NA	14-301
33	Fruit juice (any flavour)	Standard	NA	14-301
33	Fruit juice (any flavour)	Standard	NA	14-301
110	Gammon	Standard	NA	19-022
110	Gammon	Standard	NA	19-022
34	Garlic bread	Standard	NA	11-460
35	Gravy	Standard	NA	17-311
35	Gravy	Standard	NA	17-311
35	Gravy	Standard	NA	17-311
36	Ham	Standard	NA	19-022
36	Ham	Standard	NA	19-022
37	Honey	Standard	NA	17-050
37	Honey	Standard	NA	17-050
38	Hot chocolate	Standard	NA	17-532
38	Hot chocolate	Standard	NA	17-532
39	Ice cream (any flavour)	Standard	NA	12-387
39	Ice cream (any flavour)	Standard	NA	12-387
39	Ice cream (any flavour)	Standard	NA	12-387
40	Ice lolly	Fruit	NA	12-389
40	Ice lolly	Ice cream cone	NA	12-390
41	Jam	Standard	NA	17-078
41	Jam	Standard	NA	17-078
42	Kebab (in pitta bread)	Standard	NA	19-130
42	Kebab (in pitta bread)	Standard	NA	19-130
43	Kebab meat	Standard	NA	19-129
43	Kebab meat	Standard	NA	19-129
44	Lager	Standard	NA	17-211
44	Lager	Standard	NA	17-211
44	Lager	Standard	NA	17-211
44	Lager	Standard	NA	17-211
45	Lamb	Standard	NA	18-100
45	Lamb	Standard	NA	18-100
89	Lasagne	Meat with added vegetables	NA	00-010
89	Lasagne	Vegetable/vegetarian	NA	15-189
89	Lasagne	Meat	NA	19-346
46	Lentils	Standard	NA	50-711
47	Liqueur	Standard	NA	17-245
48	Macaroni cheese	Standard	NA	11-562
49	Margarine	Regular	NA	17-021
49	Margarine	Regular	NA	17-021
49	Margarine	Regular	NA	17-021
49	Margarine	Reduced fat	NA	17-027
49	Margarine	Reduced fat	NA	17-027
49	Margarine	Reduced fat	NA	17-027
109	Marmalade	Standard	NA	17-078

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
109	Marmalade	Standard	NA	17-078
50	Mayonnaise	Regular	NA	17-510
50	Mayonnaise	Regular	NA	17-510
50	Mayonnaise	Reduced fat	NA	17-511
50	Mayonnaise	Reduced fat	NA	17-511
90	Meat alternative	Standard	NA	13-455
90	Meat alternative	Standard	NA	13-455
90	Meat alternative	Standard	NA	13-455
51	Milk	Skimmed	NA	12-307
51	Milk	Skimmed	NA	12-307
51	Milk	Skimmed	NA	12-307
51	Milk	Semi skimmed	NA	12-313
51	Milk	Semi skimmed	NA	12-313
51	Milk	Semi skimmed	NA	12-313
51	Milk	Whole	NA	12-316
51	Milk	Whole	NA	12-316
51	Milk	Whole	NA	12-316
51	Milk	Non diary	NA	12-331
51	Milk	Non diary	NA	12-331
51	Milk	Non diary	NA	12-331
52	Milkshake (any flavour)	Standard	NA	12-327
52	Milkshake (any flavour)	Standard	NA	12-327
52	Milkshake (any flavour)	Standard	NA	12-327
52	Milkshake (any flavour)	Standard	NA	12-327
91	Moussaka	Meat with added vegetables	NA	00-011
91	Moussaka	Vegetable/vegetarian	NA	15-206
91	Moussaka	Meat	NA	19-248
53	Muesli	Standard	NA	11-495
53	Muesli	Standard	NA	11-495
53	Muesli	Standard	NA	11-495
54	Naan	Standard	NA	11-463
55	Noodles	Standard	NA	50-028
113	Nuts	Standard	NA	50-990
113	Nuts	Standard	NA	50-990
113	Nuts	Standard	NA	50-990
113	Nuts	Standard	NA	50-990
113	Nuts	Standard	NA	50-990
56	Other pulses	Standard	NA	13-430
56	Other pulses	Standard	NA	13-430
119	Parmesan (Parmo)	Parmesan only	NA	00-087
119	Parmesan (Parmo)	With chips	NA	00-088
119	Parmesan (Parmo)	With salad	NA	00-089
119	Parmesan (Parmo)	With chips and salad	NA	00-090
57	Pasta	White	NA	11-453
57	Pasta	White	NA	11-453
57	Pasta	White	NA	11-453

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
57	Pasta	Wholemeal	NA	11-455
57	Pasta	Wholemeal	NA	11-455
57	Pasta	Wholemeal	NA	11-455
103	Pastry	Standard	NA	11-538
103	Pastry	Standard	NA	11-538
112	Pasty	Vegetable	NA	15-377
112	Pasty	Vegetable	NA	15-377
112	Pasty	Meat	NA	19-069
112	Pasty	Meat	NA	19-069
120	Peanut butter	Standard	NA	14-876
58	Pie (savoury)	Vegetable	NA	15-377
58	Pie (savoury)	Vegetable	NA	15-377
58	Pie (savoury)	Meat	NA	19-069
58	Pie (savoury)	Meat	NA	19-069
59	Pie (sweet)	White	NA	11-465
59	Pie (sweet)	Standard	NA	11-597
59	Pie (sweet)	Standard	NA	11-597
59	Pie (sweet)	Standard	NA	11-597
60	Pitta bread	Wholemeal	NA	11-476
61	Pizza	Meat and vegetable topping	NA	00-013
61	Pizza	Meat and vegetable topping	NA	00-013
61	Pizza	Meat and vegetable topping	NA	00-013
61	Pizza	Meat and vegetable topping	NA	00-013
61	Pizza	No topping (cheese and tomato only)	NA	11-553
61	Pizza	No topping (cheese and tomato only)	NA	11-553
61	Pizza	No topping (cheese and tomato only)	NA	11-553
61	Pizza	No topping (cheese and tomato only)	NA	11-553
61	Pizza	Meat topping	NA	11-556
61	Pizza	Meat topping	NA	11-556
61	Pizza	Meat topping	NA	11-556
61	Pizza	Meat topping	NA	11-556
61	Pizza	Vegetable topping	NA	11-557
61	Pizza	Vegetable topping	NA	11-557
61	Pizza	Vegetable topping	NA	11-557
61	Pizza	Vegetable topping	NA	11-557
62	Popcorn	Standard	NA	17-131
62	Popcorn	Standard	NA	17-131
63	Porridge	Standard	NA	11-570
63	Porridge	Standard	NA	11-570
63	Porridge	Standard	NA	11-570

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
64	Potatoes	Standard	N	13-421
64	Potatoes	Standard	N	13-421
64	Potatoes	Standard	N	13-421
64	Potatoes	Standard	Y	50-672
64	Potatoes	Standard	Y	50-672
64	Potatoes	Standard	Y	50-672
92	Ravioli	Meat with added vegetables	NA	00-014
92	Ravioli	Meat	NA	11-621
117	Red sauce	Standard	NA	17-513
117	Red sauce	Standard	NA	17-513
65	Rice	Wholemeal	NA	11-443
65	Rice	Wholemeal	NA	11-443
65	Rice	Wholemeal	NA	11-443
65	Rice	Egg fried	NA	11-444
65	Rice	Egg fried	NA	11-444
65	Rice	Egg fried	NA	11-444
65	Rice	White	NA	11-446
65	Rice	White	NA	11-446
65	Rice	White	NA	11-446
93	Risotto	Standard	NA	15-378
93	Risotto	Standard	NA	15-378
93	Risotto	Standard	NA	15-378
94	Rye bread	Standard	NA	00-015
66	Salad cream	Reduced fat	NA	17-327
66	Salad cream	Reduced fat	NA	17-327
66	Salad cream	Regular	NA	17-512
66	Salad cream	Regular	NA	17-512
67	Salad dressing	Regular	NA	17-509
67	Salad dressing	Reduced fat	NA	17-538
95	Samosa	Vegetable	NA	15-305
95	Samosa	Vegetable	NA	15-305
95	Samosa	Vegetable	NA	15-305
95	Samosa	Meat	NA	19-326
95	Samosa	Meat	NA	19-326
95	Samosa	Meat	NA	19-326
104	Sandwich	White bread, meat filling	NA	00-019
104	Sandwich	White bread, meat filling	NA	00-020
104	Sandwich	White bread, meat filling with salad	NA	00-021
104	Sandwich	White bread, meat filling with salad	NA	00-022
104	Sandwich	Wholemeal/granary bread, meat filling	NA	00-023
104	Sandwich	Wholemeal/granary bread, meat filling	NA	00-024
104	Sandwich	Wholemeal/granary bread,	NA	00-025

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
		meat filling with salad		
104	Sandwich	Wholemeal/granary bread, meat filling with salad	NA	00-026
104	Sandwich	White bread, fish/seafood filling	NA	00-027
104	Sandwich	White bread, fish/seafood filling	NA	00-028
104	Sandwich	White bread, fish/seafood filling with salad	NA	00-029
104	Sandwich	White bread, fish/seafood filling with salad	NA	00-030
104	Sandwich	Wholemeal/granary, fish/seafood filling	NA	00-031
104	Sandwich	Wholemeal/granary, fish/seafood filling	NA	00-032
104	Sandwich	Wholemeal/granary, fish/seafood filling with salad	NA	00-033
104	Sandwich	Wholemeal/granary, fish/seafood filling with salad	NA	00-034
104	Sandwich	White bread, cheese filling	NA	00-035
104	Sandwich	White bread, cheese filling	NA	00-036
104	Sandwich	White bread, cheese filling with salad	NA	00-037
104	Sandwich	White bread, cheese filling with salad	NA	00-038
104	Sandwich	Wholemeal/granary bread, cheese filling	NA	00-039
104	Sandwich	Wholemeal/granary bread, cheese filling	NA	00-040
104	Sandwich	Wholemeal/granary bread, cheese filling with salad	NA	00-041
104	Sandwich	Wholemeal/granary bread, cheese filling with salad	NA	00-042
104	Sandwich	White bread, egg filling	NA	00-043
104	Sandwich	White bread, egg filling	NA	00-044
104	Sandwich	White bread, egg filling with salad	NA	00-045
104	Sandwich	White bread, egg filling with salad	NA	00-046
104	Sandwich	Wholemeal/granary bread, egg filling	NA	00-047
104	Sandwich	Wholemeal/granary bread, egg filling	NA	00-048
104	Sandwich	Wholemeal/granary bread, egg filling with salad	NA	00-049
104	Sandwich	Wholemeal/granary bread,	NA	00-050

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
		egg filling with salad		
104	Sandwich	White bread, salad filling	NA	00-051
104	Sandwich	White bread, salad filling	NA	00-052
104	Sandwich	Wholemeal/granary bread, salad filling	NA	00-053
104	Sandwich	Wholemeal/granary bread, salad filling	NA	00-054
104	Sandwich	White bread, peanut butter filling	NA	00-079
104	Sandwich	White bread, peanut butter filling	NA	00-080
104	Sandwich	Wholemeal/granary bread, peanut butter filling	NA	00-081
104	Sandwich	Wholemeal/granary bread, peanut butter filling	NA	00-082
104	Sandwich	White bread, jam filling	NA	00-083
104	Sandwich	White bread, jam filling	NA	00-084
104	Sandwich	Wholemeal/granary bread, jam filling	NA	00-085
104	Sandwich	Wholemeal/granary bread, jam filling	NA	00-086
68	Sausage	Standard	Y	19-079
68	Sausage	Standard	Y	19-079
68	Sausage	Standard	Y	19-079
68	Sausage	Standard	N	19-080
68	Sausage	Standard	N	19-080
68	Sausage	Standard	N	19-080
96	Savoury sauce	Standard	NA	17-528
96	Savoury sauce	Standard	NA	17-528
96	Savoury sauce	Standard	NA	17-528
69	Seeds	Standard	NA	50-990
69	Seeds	Standard	NA	50-990
69	Seeds	Standard	NA	50-990
69	Seeds	Standard	NA	50-990
69	Seeds	Standard	NA	50-990
70	Shellfish	Standard	NA	16-239
97	Shepards pie	Meat with added vegetables	NA	00-016
97	Shepards pie	Vegetarian/vegetable	NA	15-313
97	Shepards pie	Meat	NA	19-216
71	Soup	Diet	NA	17-265
71	Soup	Diet	NA	17-265
71	Soup	Diet	NA	17-265
71	Soup	Diet	NA	17-265
71	Soup	Reduced fat	NA	17-280
71	Soup	Reduced fat	NA	17-280
71	Soup	Reduced fat	NA	17-280
71	Soup	Reduced fat	NA	17-280

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
111	Spaghetti	White	NA	11-453
111	Spaghetti	White	NA	11-453
111	Spaghetti	White	NA	11-453
111	Spaghetti	Wholemeal	NA	11-455
111	Spaghetti	Wholemeal	NA	11-455
111	Spaghetti	Wholemeal	NA	11-455
98	Spaghetti bolognese	Meat with added vegetables	NA	00-017
98	Spaghetti bolognese	Meat (without pasta)	NA	19-328
98	Spaghetti bolognese	Meat (with pasta)	NA	19-353
83	Spirit	Standard	NA	17-247
72	Squash (any flavour)	Standard	NA	17-195
72	Squash (any flavour)	Standard	NA	17-195
72	Squash (any flavour)	Standard	NA	17-195
100	Stew	Meat with added vegetables	NA	00-018
100	Stew	Meat with added vegetables	NA	00-018
100	Stew	Meat with added vegetables	NA	00-018
100	Stew	Vegetable	NA	15-368
100	Stew	Vegetable	NA	15-368
100	Stew	Vegetable	NA	15-368
100	Stew	Meat	NA	19-334
100	Stew	Meat	NA	19-334
100	Stew	Meat	NA	19-334
73	Sugar	Standard	NA	17-063
73	Sugar	Standard	NA	17-063
74	Sweets (not chocolate)	Standard	NA	17-117
74	Sweets (not chocolate)	Standard	NA	17-117
74	Sweets (not chocolate)	Standard	NA	17-117
75	Syrup	Standard	NA	17-065
76	Tea	With milk	NA	00-055
76	Tea	With milk, with sweetener	NA	00-055
76	Tea	With milk	NA	00-056
76	Tea	With milk, with sweetener	NA	00-056
76	Tea	Without milk, with sugar	NA	00-073
76	Tea	Without milk, with sugar	NA	00-074
76	Tea	Without milk	NA	17-165
76	Tea	Without milk, with sweetener	NA	17-165
76	Tea	Without milk	NA	17-165
76	Tea	Without milk, with sweetener	NA	17-165
77	Toast	White, with butter/margarine	NA	00-059
77	Toast	White, with jam/marmalade/honey	NA	00-060

Food ID	Description	Sub group	Cooked in fat	MW/Recipe Code
77	Toast	White, with butter and jam/marmalade/honey	NA	00-061
77	Toast	White, with peanut butter	NA	00-062
77	Toast	Granary, with butter/margarine	NA	00-063
77	Toast	Granary, with jam/marmalade/honey	NA	00-064
77	Toast	Granary, with butter and jam/marmalade/honey	NA	00-065
77	Toast	Granary, with peanut butter	NA	00-066
77	Toast	Wholemeal, with butter/margarine	NA	00-067
77	Toast	Wholemeal, with jam/marmalade/honey	NA	00-068
77	Toast	Wholemeal, with butter and jam/marmalade/honey	NA	00-069
77	Toast	Wholemeal, with peanut butter	NA	00-070
77	Toast	White	NA	11-475
77	Toast	Granary (brown with bits)	NA	11-611
77	Toast	Wholemeal (brown)	NA	11-611
101	Tofu	Standard	NA	50-723
78	Tomato ketchup	Standard	NA	17-513
78	Tomato ketchup	Standard	NA	17-513
114	Treacle	Standard	NA	17-065
102	Vegetables	Standard	N	13-446
102	Vegetables	Standard	Y	50-795
79	Water	Standard	NA	00-000
79	Water	Standard	NA	00-000
79	Water	Standard	NA	00-000
79	Water	Standard	NA	00-000
79	Water	Standard	NA	00-000
79	Water	Standard	NA	00-000
80	Wine	Standard	NA	17-231
81	Yogurt	Regular	NA	12-375
81	Yogurt	Regular	NA	12-375
81	Yogurt	Reduced fat	NA	12-380
81	Yogurt	Reduced fat	NA	12-380
82	Yorkshire pudding	Standard	NA	11-607

Appendix B Physical activity item list

PA ID	Activity	Difficulty	Code from compendium	MET
1	Aerobics	Hard	3015	7
1	Aerobics	Low	3020	5
1	Aerobics	Moderate	3021	6.5
10	Dancing	Hard	3030	5.5
10	Dancing	Low	3040	3
10	Dancing	Moderate	3031	4.5
11	Darts	Hard	15180	2.5
11	Darts	Low	15180	2.5
11	Darts	Moderate	15180	2.5
12	DIY	Hard	6050	6
12	DIY	Low	6160	3
12	DIY	Moderate	6165	4.5
13	Driving a car	Hard	16010	2
13	Driving a car	Low	16010	2
13	Driving a car	Moderate	16010	2
14	Driving a lorry, tractor, bus	Hard	16050	3
14	Driving a lorry, tractor, bus	Low	16050	3
14	Driving a lorry, tractor, bus	Moderate	16050	3
15	Fishing	Hard	4001	3
15	Fishing	Low	4001	3
15	Fishing	Moderate	4001	3
16	Football	Hard	15605	10
16	Football	Low	0002	4
16	Football	Moderate	15610	7
17	Gardening	Hard	8245	3.5
17	Gardening	Low	8245	2.8
17	Gardening	Moderate	8245	3
18	Golf	Hard	15255	4.5
18	Golf	Low	15255	4.5
18	Golf	Moderate	15255	4.5
19	Gymnastics	Hard	15300	4
19	Gymnastics	Low	15300	4
19	Gymnastics	Moderate	15300	4
2	Arts and crafts	Hard	9080	2
2	Arts and crafts	Low	9080	2
2	Arts and crafts	Moderate	9080	2
20	Hockey	Hard	15350	8
20	Hockey	Low	15350	8
20	Hockey	Moderate	15350	8
21	Horse riding	Hard	11390	8
21	Horse riding	Low	15400	2.5
21	Horse riding	Moderate	15390	6.5

PA ID	Activity	Difficulty	Code from compendium	MET
21	Rock climbing	Hard	15535	11
21	Rock climbing	Low	0003	5
21	Rock climbing	Moderate	15540	8
22	Housework	Hard	5027	3
22	Housework	Low	5025	2.3
22	Housework	Moderate	5026	2.5
23	Ice skating	Hard	19040	9
23	Ice skating	Low	19020	5.5
23	Ice skating	Moderate	19030	7
24	Judo	Hard	15430	10
24	Judo	Low	15430	10
24	Judo	Moderate	15430	10
25	Listening to music	Hard	7021	1
25	Listening to music	Low	7021	1
25	Listening to music	Moderate	7021	1
26	Netball	Hard	15040	8
26	Netball	Low	15070	4.5
26	Netball	Moderate	15050	6
27	Playing a musical intrument	Hard	10070	2.5
27	Playing a musical intrument	Low	10070	2.5
27	Playing a musical intrument	Moderate	10070	2.5
28	Reading	Hard	9055	1.5
28	Reading	Low	9055	1.5
28	Reading	Moderate	9055	1.5
29	Riding in car/bus	Hard	16015	1
29	Riding in car/bus	Low	16015	1
29	Riding in car/bus	Moderate	16015	1
3	Badminton	Hard	15020	7
3	Badminton	Low	0001	3
3	Badminton	Moderate	15030	4.5
30	Riding motor cycle	Hard	16030	2.5
30	Riding motor cycle	Low	16030	2.5
30	Riding motor cycle	Moderate	16030	2.5
32	Rugby	Hard	15560	10
32	Rugby	Low	0004	4
32	Rugby	Moderate	15610	7
33	Running	Hard	12070	11.5
33	Running	Low	12030	8
33	Running	Moderate	12050	10
34	Shopping	Hard	5065	2.3
34	Shopping	Low	5065	2.3
34	Shopping	Moderate	5065	2.3
35	Sitting operating machinery	Hard	11590	2.5

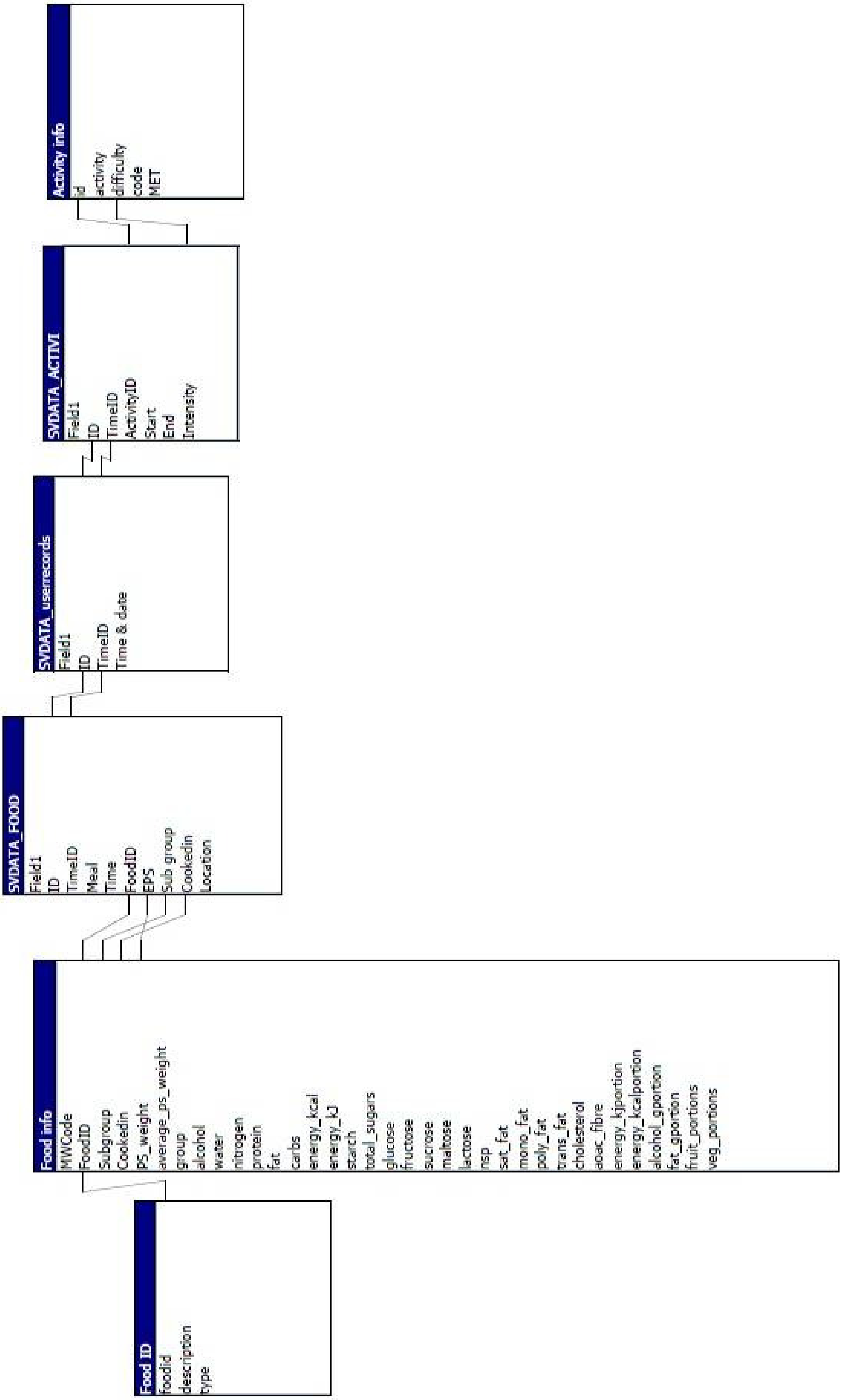
PA ID	Activity	Difficulty	Code from compendium	MET
35	Sitting operating machinery	Low	11590	2.5
35	Sitting operating machinery	Moderate	11590	2.5
36	Sitting talking, reading, writing, typing	Hard	9040	1.8
36	Sitting talking, reading, writing, typing	Low	9040	1.8
36	Sitting talking, reading, writing, typing	Moderate	9040	1.8
37	Skiing	Hard	19170	8
37	Skiing	Low	19150	5
37	Skiing	Moderate	19160	6
38	Sleeping	Hard	7030	0.9
38	Sleeping	Low	7030	0.9
38	Sleeping	Moderate	7030	0.9
39	Snooker	Hard	15080	2.5
39	Snooker	Low	15080	2.5
39	Snooker	Moderate	15080	2.5
4	Bowls	Hard	15090	3
4	Bowls	Low	15090	3
4	Bowls	Moderate	15090	3
40	Squash	Hard	15650	12
40	Squash	Low	15650	12
40	Squash	Moderate	15650	12
41	Standing manual work	Hard	11610	3
41	Standing manual work	Low	11610	3
41	Standing manual work	Moderate	11610	3
42	Standing quietly	Hard	7040	1.2
42	Standing quietly	Low	7040	1.2
42	Standing quietly	Moderate	7040	1.2
43	Standing reading, talking, filing	Hard	11600	2.3
43	Standing reading, talking, filing	Low	11600	2.3
43	Standing reading, talking, filing	Moderate	11600	2.3
44	Swimming	Hard	18230	10
44	Swimming	Low	18310	6
44	Swimming	Moderate	18240	7
45	Table tennis	Hard	15660	4
45	Table tennis	Low	15660	4
45	Table tennis	Moderate	15660	4
46	Tennis	Hard	15675	7
46	Tennis	Low	15675	7
46	Tennis	Moderate	15675	7
47	Walking	Hard	17220	3.8
47	Walking	Low	17170	2

PA ID	Activity	Difficulty	Code from compendium	MET
47	Walking	Moderate	17200	3
49	Watching TV/DVD	Hard	7020	1
49	Watching TV/DVD	Low	7020	1
49	Watching TV/DVD	Moderate	7020	1
5	Bowling	Hard	15090	3
5	Bowling	Low	15090	3
5	Bowling	Moderate	15090	3
50	Water sports	Hard	18060	12
50	Water sports	Low	18040	3
50	Water sports	Moderate	18050	7
51	Weight training	Hard	2050	6
51	Weight training	Low	2050	6
51	Weight training	Moderate	2050	6
52	Yoga	Hard	2100	2.5
52	Yoga	Low	2100	2.5
52	Yoga	Moderate	2100	2.5
54	Looking after children	Hard	5180	3
54	Looking after children	Low	5170	2.5
54	Looking after children	Moderate	5175	2.8
55	Sexual activity	Hard	14010	1.5
55	Sexual activity	Low	14030	1
55	Sexual activity	Moderate	14020	1.3
56	Exercises - calisthenics	Hard	2020	8
56	Exercises - calisthenics	Low	2030	3.5
56	Exercises - calisthenics	Moderate	0005	5.7
57	Carpentary	Hard	13000	8
57	Carpentary	Low	11300	8
57	Carpentary	Moderate	11300	8
58	Farming	Hard	13000	8
58	Farming	Low	11300	8
58	Farming	Moderate	11300	8
59	Forestry	Hard	13000	8
59	Forestry	Low	11300	8
59	Forestry	Moderate	11300	8
6	Construction work	Hard	13000	8
6	Construction work	Low	11300	8
6	Construction work	Moderate	11300	8
60	Baseball	Hard	15150	5
60	Baseball	Low	15150	5
60	Baseball	Moderate	15150	5
61	Rounders	Hard	15150	5
61	Rounders	Low	15150	5
61	Rounders	Moderate	15150	5
62	Kick around	Hard	15605	10
62	Kick around	Low	0002	4
62	Kick around	Moderate	15610	7
63	Household tasks	Hard	5027	3

PA ID	Activity	Difficulty	Code from compendium	MET
63	Household tasks	Low	5025	2.3
63	Household tasks	Moderate	5026	2.5
64	Roller blading	Hard	19040	9
64	Roller blading	Low	19020	5.5
64	Roller blading	Moderate	19030	7
65	Skateboarding	Hard	19040	9
65	Skateboarding	Low	19020	5.5
65	Skateboarding	Moderate	19030	7
66	Kick boxing	Hard	15430	10
66	Kick boxing	Low	15430	10
66	Kick boxing	Moderate	15430	10
67	Karate	Hard	15430	10
67	Karate	Low	15430	10
67	Karate	Moderate	15430	10
68	Tae kwan do	Hard	15430	10
68	Tae kwan do	Low	15430	10
68	Tae kwan do	Moderate	15430	10
69	Self defence	Hard	15430	10
69	Self defence	Low	15430	10
69	Self defence	Moderate	15430	10
7	Cooking	Hard	5050	2
7	Cooking	Low	5050	2
7	Cooking	Moderate	5050	2
70	Basketball	Hard	15040	8
70	Basketball	Low	15070	4.5
70	Basketball	Moderate	15050	6
71	Writing	Hard	9055	1.5
71	Writing	Low	9055	1.5
71	Writing	Moderate	9055	1.5
72	Talking on the telephone	Hard	9055	1.5
72	Talking on the telephone	Low	9055	1.5
72	Talking on the telephone	Moderate	9055	1.5
73	Jogging	Hard	12070	11.5
73	Jogging	Low	12030	8
73	Jogging	Moderate	12050	10
74	Snowboarding	Hard	19170	8
74	Snowboarding	Low	19150	5
74	Snowboarding	Moderate	19160	6
75	Napping	Hard	7030	0.9
75	Napping	Low	7030	0.9
75	Napping	Moderate	7030	0.9
76	Watching a film at the cinema	Hard	7020	1
76	Watching a film at the	Low	7020	1

PA ID	Activity	Difficulty	Code from compendium	MET
	cinema			
76	Watching a film at the cinema	Moderate	7020	1
77	Playing computer games - sitting	Hard	9040	1.8
77	Playing computer games - sitting	Low	9040	1.8
77	Playing computer games - sitting	Moderate	9040	1.8
78	Playing computer games - active	Hard	3030	5.5
78	Playing computer games - active	Low	3040	3
78	Playing computer games - active	Moderate	3031	4.5
79	Working on a computer	Hard	9040	1.8
79	Working on a computer	Low	9040	1.8
79	Working on a computer	Moderate	9040	1.8
8	Cricket	Hard	15150	5
8	Cricket	Low	15150	5
8	Cricket	Moderate	15150	5
80	Pilates	Hard	2100	2.5
80	Pilates	Low	2100	2.5
80	Pilates	Moderate	2100	2.5
9	Cycling	Hard	1040	10
9	Cycling	Low	1020	6
9	Cycling	Moderate	1030	8

Appendix C Database relationships



Appendix D SQL Queries

SQL Query 1
SELECT SVDATA_userrecords.ID, SVDATA_userrecords.[Date and time], [Activity info].activity, SVDATA_ACTIVI.[Time start], SVDATA_ACTIVI.[Time end], [Activity info].MET
FROM SVDATA_userrecords INNER JOIN (SVDATA_ACTIVI INNER JOIN [Activity info] ON (SVDATA_ACTIVI.Intensity = [Activity info].difficulty) AND (SVDATA_ACTIVI.ActivityID = [Activity info].id)) ON (SVDATA_userrecords.ID = SVDATA_ACTIVI.ID) AND (SVDATA_userrecords.TimeID = SVDATA_ACTIVI.TimeID);

SQL Query 2
SELECT [Processed activity data].ID, [Processed activity data].[Date and time], Sum([Processed activity data].[Min MVPA]) AS [SumOfMin MVPA]
FROM [Processed activity data]
GROUP BY [Processed activity data].ID, [Processed activity data].[Date and time];

SQL Query 3
SELECT [QUERY 2: Sum MVPA each day].ID, Avg([QUERY 2: Sum MVPA each day].[SumOfMin MVPA]) AS [AvgOfSumOfMin MVPA]
FROM [QUERY 2: Sum MVPA each day]
GROUP BY [QUERY 2: Sum MVPA each day].ID;

SQL Query 4
SELECT SVDATA_userrecords.ID, SVDATA_userrecords.[Date and time], SVDATA_FOOD.Meal, SVDATA_FOOD.Time, [Food ID].description, [Food info].Subgroup, [Food info].Cookedin, [Food info].energy_kjportion, [Food info].energy_kcalportion, [Food info].alcohol_gportion, [Food info].fat_gportion, [Food info].fruit_portions, [Food info].veg_portions
FROM SVDATA_userrecords INNER JOIN (([Food ID] INNER JOIN [Food info] ON [Food ID].foodid = [Food info].FoodID) INNER JOIN SVDATA_FOOD ON ([Food info].FoodID = SVDATA_FOOD.FoodID) AND ([Food info].Subgroup = SVDATA_FOOD.[Sub group]) AND ([Food info].PS_weight = SVDATA_FOOD.EPS) AND ([Food info].Cookedin = SVDATA_FOOD.Cookedin) AND ([Food ID].foodid = SVDATA_FOOD.FoodID)) ON (SVDATA_userrecords.ID = SVDATA_FOOD.ID) AND (SVDATA_userrecords.TimeID = SVDATA_FOOD.TimeID);

SQL Query 5
SELECT [QUERY 4: Food data].ID, [QUERY 4: Food data].[Date and time], Sum([QUERY 4: Food data].energy_kjportion) AS SumOfenergy_kjportion
FROM [QUERY 4: Food data]
GROUP BY [QUERY 4: Food data].ID, [QUERY 4: Food data].[Date and time];

SQL Query 6
SELECT [QUERY 5: Sum diet variables each day].ID, Avg([QUERY 5: Sum diet variables each day].SumOfenergy_kjportion) AS AvgOfSumOfenergy_kjportion
FROM [QUERY 5: Sum diet variables each day]

GROUP BY [QUERY 5: Sum diet variables each day].ID;

SQL Query 7

```
SELECT [QUERY 4: Food data].ID, [QUERY 4: Food data].[Date and time], [QUERY 4: Food data].description
FROM [QUERY 4: Food data]
WHERE ((([QUERY 4: Food data].description)="baked beans"));
```

SQL Query 8

```
SELECT [QUERY 4: Food data].ID, [QUERY 4: Food data].[Date and time], [QUERY 4: Food data].description
FROM [QUERY 4: Food data]
WHERE ((([QUERY 4: Food data].description) Like "*pulses"));
```

SQL Query 9

```
SELECT [QUERY 4: Food data].ID, [QUERY 4: Food data].[Date and time], [QUERY 4: Food data].description
FROM [QUERY 4: Food data]
WHERE ((([QUERY 4: Food data].description) Like "fruit juice*"));
```

SQL Query 10

```
SELECT [QUERY 5: Baked Beans].ID, [QUERY 5: Baked Beans].[Date and time],
Count([QUERY 5: Baked Beans].description) AS CountOfdescription
FROM [QUERY 5: Baked Beans]
GROUP BY [QUERY 5: Baked Beans].ID, [QUERY 5: Baked Beans].[Date and time];
```

SQL Query 11

```
SELECT [QUERY 6: Other pulses].ID, [QUERY 6: Other pulses].[Date and time],
Count([QUERY 6: Other pulses].description) AS CountOfdescription
FROM [QUERY 6: Other pulses]
GROUP BY [QUERY 6: Other pulses].ID, [QUERY 6: Other pulses].[Date and time];
```

SQL Query 12

```
SELECT [QUERY 7: Fruit juice].ID, [QUERY 7: Fruit juice].[Date and time],
Count([QUERY 7: Fruit juice].description) AS CountOfdescription
FROM [QUERY 7: Fruit juice]
GROUP BY [QUERY 7: Fruit juice].ID, [QUERY 7: Fruit juice].[Date and time];
```

Appendix E Excel templates

Physical activity variables

	A	B	C	D	E	F	G	H
1	ID	Date recalled	activity	Start time	End time	Duration (mins)	MET	Min MVPA
2	173	30/10/09	Aerobics	1630	1745	75	6.5	75
Formula						=SUM(((INT(E2/100)*60)+(((E2/100)-INT(E2/100))*100))-((INT(D2/100)*60)+(((D2/100)-INT(D2/100))*100)))		=IF(G2>=3,F2,0)

Dietary variables

	A	B	C	D	E	F	G	H	I
1	ID	Energy (kJ)	Alc (g)	Fat (g)	Food energy (kJ)	%food energy fat	Fruit portion	Veg portion	Total FV
2	123	7238.3	30.1	64.0	6367.0	37.2	2	3	5
Formula					=SUM(B2-(C2*29))	=SUM((D2*37)/E2)*100			=SUM(G2:H2)

	J	K	L	M	N	O
1	Portion FJ	Portion BB	Portion other pulses	Portions BB & OP	Total FV_cor FJ	Total FV_cor FJ & BB/OP
2	2	1	1	2	4	3
Formula				=SUM(K2:L2)	=IF(J2>1,I2-J2+1,I2)	=IF(M2>1,N2-M2+1,N2)

Appendix F Ethical approval for usability testing, test-retest and preliminary method comparison

Providing **Opportunities** - Pursuing **Excellence**

UNIVERSITY OF **TEESSIDE**

PRIVATE AND CONFIDENTIAL

Direct Line: 01642 384154

17th April 2007

Carolyn Summerbell
School of Health & Social Care
University of Teesside

Dear Carolyn

Study 052/07 – The evaluation of a population health initiative (Teesside on the Move) website and an online assessment tool to measure dietary intake and physical behaviours in adults. Researcher: Sean Crooks, David Cumbor, Darren Flynn, Frances Hillier, Claire Tupling Supervisor: Carolyn Summerbell

Thank you for resubmitting the changes to the above proposal. I acknowledge that the comments raised by the Research Governance and Ethics Committee have been addressed as discussed with myself, and therefore, through Chair's action the study can now proceed.

The School of Health & Social Care Research Ethics Committee wish you well with your study.

Yours sincerely

Tricia Forster

Tricia Forster
Chair
Research Ethics Committee
School of Health & Social Care

INVESTOR IN PEOPLE

POSITIVE ABOUT DISABLED PEOPLE

VAT REG NO. GB 686 4809 81

Professor Paul Keane
Dean
SCHOOL OF HEALTH & SOCIAL CARE
UNIVERSITY OF TEESSIDE MIDDLESBROUGH
TEES VALLEY TS1 3BA UK
TEL: +44 (0)1642 384100 FAX: +44 (0)1642 384105
www.tees.ac.uk

Appendix G Recruitment poster/leaflet for the usability testing

CAN YOU HELP?

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

Researchers at the University of Teesside have been awarded half a million pounds by the Food Standards Agency to carry out a major research study that aims to improve the diet and physical activity level of people living in Middlesbrough.

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

We are looking for people to test a new online computer tool that collects information on your diet and physical activity behaviours

The study will involve you completing the online computer tool and telling us what you think of it

The study will take place at the University of Teesside during the weeks beginning 11th and 18th June. You will be asked to attend a 1 hour session at a time convenient for you. Refreshments and travel expenses will be provided, and you will receive a £10 high street shopping voucher.

Interested?
Please take an information sheet and return a contact form in the prepaid envelope provided, or contact:

Frances Hillier
Centre for Food, Physical Activity and Obesity,
School of Health and Social Care, University of Teesside, TS1 3BA
Tel: 01642 342757 or 01642 384111
Email: f.hillier@tees.ac.uk

Appendix H Participant information sheet for the usability testing

UNIVERSITY OF TEESSIDE

The evaluation an online assessment tool to measure dietary intake and physical activity behaviours in adults

INFORMATION SHEET

Thank you for thinking about taking part in our research study. Before you decide if you would like to put your name forward to take part, please take the time to read this information, and feel free to discuss it with your family or friends. Please contact us (contact details for Frances Hillier are printed at the end of this leaflet) if you want to ask us any questions about the study.

Who are we?

We are researchers at the University of Teesside who have been awarded half a million pounds by the Food Standards Agency to carry out a major research study that aims to improve the diet and physical activity level of people living in Middlesbrough.

We are developing an exciting new online computer tool designed to measure dietary intake and physical activity behaviours. We are looking for 10 people like you to help us test the new online computer tool to make sure it is user friendly.

What will the study involve?

You will be invited to attend a session, at a time convenient to you during the weeks beginning 11th and 18th of June 2007, at the University of Teesside where the study will take place (travel expenses will be provided). Before taking part in the study you will be given the opportunity to ask any questions and be asked to fill in a consent form. The study will involve completing the online tool. We will ask you to think aloud when doing this so that we can identify any problems with the tool. A special computer programme will video-record the computer screen and tape-record your comments as you complete the online computer tool. At the end of the study we will ask you to fill in a feedback question asking you what you thought of the tool and if you have any suggestions for improvements. The session should take about an hour and refreshments will be available. All participants who take part in the study will receive a £10 high street shopping voucher.

Taking part in this study is entirely voluntary and you can withdraw at any time without giving any reason and without any of your rights being affected.

All information collected during the study will be anonymised and will remain within locked filing cabinets and password protected files on computers at the University of Teesside. Only researchers working on the study will have access to the information and responses will not be discussed with any third party. Once the research is finished, the collected data will be destroyed. A summary of the results of the study will be available on request.

How to take part

If you are interested in taking part in the study, please fill in a contact form and return it to researchers in one of the prepaid envelops provided.

Thank you for taking time to read this information sheet.

If you have any further questions please contact:

Frances Hillier
Centre for Food, Physical Activity and Obesity,
School of Health and Social Care, University of Teesside, TS1 3BA

Tel: 01642 342757
Email: f.hillier@tees.ac.uk

If you would like to find out about the sort of research that we are doing at the Centre for Food, Physical Activity and Obesity, please visit our website at:

http://www.tees.ac.uk/schools/SOH/obesity.cfm

Thank you

Professor Carolyn Summerbell
Principal Investigator, University of Teesside

Appendix I Consent form for usability testing

UNIVERSITY OF
TEESSIDE

Consent Form

The evaluation of an online assessment tool to measure dietary intake and physical activity behaviours in adults

ID no

	Please tick & initial	*Advocate (where applicable)*
1. I have read and understood the information sheet about this study and have had the opportunity to ask questions.	☐	☐
2. I understand that any reports from this study will not identify my individual responses or responses to comments made during the study.	☐	☐
3. I understand that all information collected during the study will be anonymised and will remain within locked filing cabinets and password protected files on computers at the University of Teesside.	☐	☐
4. I understand that participation in this study is entirely voluntary and I can withdraw at any time without giving reason and without any of my rights being affected.	☐	☐
5. I understand that by signing and returning this form, I am consenting to participate in this study.	☐	☐

Name of participant --

Participant's signature ---

Advocate signature (if applicable) ---

Researcher's signature ---

Date ------------------------------

Appendix J Usability testing instructions for participants

The evaluation an online assessment tool to measure dietary intake and physical activity behaviours in adults

Instructions to participants

Please complete the tasks given to you by the researcher.

Please do not ask the researcher any questions during the task unless absolutely necessary.

Please **REMEMBER** this is not a test of you or your ability, it is a test of the quality of the assessment program.

You can make any comments you wish – you **CAN** swear!!

Do you have any questions before you start?

Please tell the researcher when you are ready to begin the first task.

Task 1

Please work through the data collection program, SNAP-A. After the tasks are completed for each page, click the 'Next' button to move on to the next page.

Page 1 ('typical day' questions):

Please answer the questions as appropriate to you.

Page 2:

Please enter the data below:

ACTIVITY	TIME STARTED	TIME FINISHED	DIFFICULTY
Walking	9.00am	9.30am	Low
Housework	11.00am	12.00pm	Moderate
Gardening	2.00pm	2.30pm	Moderate
Shopping	3.00pm	4.00pm	Low

Page 3:

Please read through the list, then go back to the previous page and enter the following forgotten data:

ACTIVITY	TIME STARTED	TIME FINISHED	DIFFICULTY
Walking	5.30	5.45	Low
Walking	7.00	7.15	Low

Page 4:

Please enter the data below:

TIME	LOCATION	MEAL	FOOD/DRINK(S) CONSUMED
8.30am	Home	Breakfast	Small tumbler orange juice 2 slices toast (white), with butter (regular, thinly spread) and jam (level teaspoon)
12.30pm	Home	Dinner	Ham and lettuce sandwich (made with 2 slices white bread) Can (regular size) of diet cola Chocolate bar – regular size
6.00pm	Pub	Tea	Cheeseburger and chips (medium portion), with tomato ketchup (heaped tablespoon) Pint lager

Page 5:

Please read through the list, then go back to the previous page and enter the following forgotten data:

TIME	LOCATION	MEAL	FOOD/DRINK(S) CONSUMED
2.30pm	Home	Snack	Mug of tea, milk, one level teaspoon sugar 2 chocolate digestives

Page 6:

Please answer the questions as appropriate to you. You do not have to enter your weight, if you would prefer not to.

Page 7:

Please submit the data and state in a **loud clear voice “finished”**

Task 2

You will be shown a recording of the screen while you were completing task 1. Please remember not to ask the researcher any questions.

In a clear voice, please **comment on your actions**, shown in the recording. **Please comment in time with what is happening on the screen and do not jump ahead.** We would like to know why you found any particular parts of the program **easy or difficult** and what you found **understandable or unclear.**

Just try to give as many comments as possible while the recording is being played back. You can make any comments you wish – you **CAN** swear!!

You can pause the playback at any point if you feel you want to; however, you may decide this is not necessary. The researcher will demonstrate the controls for pausing.

Do you have any questions before you start?

Please tell the researcher when you are ready to begin.

Task 3

Please have a look at the feedback page (use the mouse to scroll up and down) and make comments.

We would like to know what you think of the **appearance** of the page, if you think the page or any parts of the page are **easy or difficult to understand**, what you think of the **wording** used, how you think the page or any parts could be **improved**, if you think there are any **information missing**, and **any other comments** you would like to make.

Do you have any questions before you start?

Please tell the researcher when you are ready to begin.

Appendix K Usability testing feedback questionnaire

UNIVERSITY OF TEESSIDE

ID no

The evaluation of an online assessment tool to measure dietary intake and physical activity behaviours in adults

Computer experience

Do you own or have access to a computer?	YES/NO
Do you own or have access to a computer connected to the internet?	YES/NO
Approximately how many hours per week or month do you use a computer?	____________________________
Approximately how many hours per week or month do you use the internet?	____________________________

Feedback Questionnaire

We would like you to answer the following questions about the computer programme you were asked to use.

1a) Do you think the online computer tool was easy to follow? If no, why not?

1b) We would like you to imagine you were asked to complete the tool based on the foods and drinks **you consumed**, and the activities **you did** the previous day. Do you think it would be easy to do this using the online computer tool? If no, why not?

2a) Do you feel that the time taken to complete the online computer tool was reasonable? If no, why?

2b) We would like you to imagine you were asked to complete the tool based on the foods and drinks **you consumed**, and the activities **you did** the previous day. Do you think that the time that it would take to complete the tool would be reasonable? If no, why?

2c) Would you be happy to complete the online computer tool for more than once if it gave you a more accurate feedback?

3. Do you think the online computer tool can be improved? If yes, how?

4. Do you think there were any questions missing from the online computer tool that should be included? If yes, what would like to be included?

5. Do you have any further comments on the online computer tool?

Thank you for your help

Appendix L Usability testing researcher instructions and script

Before you begin: Run through a recording (testing the microphone) and adjust the settings to the correct size etc. Start a new recording, open the SNAPA website and log in. Leave ready for when the participant starts the first task. Make sure the volume button is turned right down.

1. Thank you for coming in today. Did you read the information sheet? I'll explain a little more about the computer tool and what will ask you to do today.
2. During the session I will ask you to complete four tasks. The first two tasks will take the majority of the time. During the first task I will ask you to complete the computer tool/questionnaire. You will be asked to answer some of the questions as appropriate to you, but for some of the questions you will be given data to enter *(show instructions)*. During the first task you can make comments as you work through the questionnaire but you can work in silence if you would like as you will be asked to comment in more detail in Task 2. In Task 2, I will show you a recording of the screen as you worked through the questionnaire and will ask you to talk through what you thought as you completed the questionnaire.
3. In Task 3, I am going to ask you to comment on the feedback pages that are produced at the end of the questionnaire, and then finally I will give you a feedback form to complete. These last 2 tasks should not take very long.
4. Are you happy with everything? Would you like to ask any questions?
5. First of all, please could you read and complete the consent form? *Participant reads and signs consent form.*
6. Please read through the instructions and let me know when you are ready to begin the first task
7. I'll press f9 the start the recording and then begin when you are ready. **Task 1**. *When participant is finished press f10. Save recording – choose 'edit recording'. Minimise SNAPA screen (if required) for use in Task 3.*
8. Please read the instructions for Task 2 and let me know when you are ready to begin. *Show participant how to play and pause the screen.* I'll press f9 to start the recording and then you when you are ready to begin, press play and start making comments on what you see. **Task 2**. *When the playback finishes* – would you like to make anymore comments. *Press f10 when participant has finished making comments. Save recording – choose 'start new recording'.*
9. Please read the instructions for Task 3 and let me know when you are ready to begin. *Bring up the feedback pages. Press f9 when participant is ready to begin, press f10 when the participant has made all the comments that they would like to make. Save recording and choose 'edit recording'.*
10. Finally, please could you complete the feedback questionnaire? *While participant is completing the questionnaire make sure all files have been saved.*
11. Thank you again. ***Give participant their voucher.***

Appendix M Recruitment poster/leaflet for the test-retest and preliminary method comparison study

CAN YOU HELP?

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

Researchers at the University of Teesside have been awarded half a million pounds by the Food Standards Agency to carry out a major research study that aims to improve the diet and physical activity level of people living in Middlesbrough.

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

We are looking for 80 people to test a new online computer tool that collects information on your diet and physical activity behaviours

The study will involve you wearing an accelerometer (a device like a pedometer that records your physical activity) for a day

AND

Taking part in a study session (see locations, times and dates below) where you will be asked to complete the online computer tool and talk to researchers about things you eat and drink, and the activities you do

During the study day we will be running a just-for-fun quiz with the chance for you to win a selection of prizes. All participants who take part in the study will receive a **£15 high street shopping voucher**.

The study session will take no longer than 3 hours. Refreshments will be provided.

We are holding following study sessions over July 2007:

Wednesday 25th July 2007 Middlesbrough City Learning Centre	10am-1.00pm **OR** 12.30pm-3.30pm
Thursday 26th July 2007 Charlbury Road Community Centre	12.30pm-3.30pm
Friday 27th July 2007 University of Teesside	10am-1.00pm **OR** 12.30pm-3.30pm

If you are interested in taking part on any of these days please ask Linthorpe Community Centre staff for an information sheet or contact:

Frances Hillier or Sarah Smith
Centre for Food, Physical Activity and Obesity,
School of Health and Social Care, University of Teesside, TS1 3BA
Tel: 01642 342757 or 384111, Fax: 01642 342770
Email: f.hillier@tees.ac.uk or sarah.smith@tees.ac.uk

Researchers MUST receive your contact details at least 3 working days before the study session you wish to attend. Thank you

Appendix N Participant information sheet for the test-retest and preliminary method comparison study

UNIVERSITY OF TEESSIDE

The evaluation of an online assessment questionnaire to measure dietary intake and physical activity behaviours in adults

INFORMATION SHEET

Thank you for thinking about taking part in our research study. Before you decide if you would like to put your name forward to take part, please take the time to read this information, and feel free to discuss it with your family or friends. Please contact us (contact details for Frances Hillier are printed at the end of this leaflet) if you want to ask us any questions about the study.

Who are we?

We are Researchers at the University of Teesside who have been awarded half a million pounds by the Food Standards Agency to carry out a major research study that aims to improve the diet and physical activity level of adults living in Middlesbrough.

We are developing an exciting new online computer questionnaire designed to measure dietary intake and physical activity behaviours. We are looking for 80 adults (18+, no maximum age) like you to help us test the new online tool to make sure that it collects accurate information of diet and physical activity.

What will the study involve?

You will be invited to meet with a researcher 2 days before the study session you wish to attend (please see locations and dates below) at a time and place convenient to you. When you meet the researcher you will have the opportunity to ask any further questions about the study. If you would still like to take part in the study you will be asked to fill in a consent form, and then you will be given an accelerometer (a small device on a belt, which is worn on the hip, under your clothes, against your skin, and measures physical activity – similar to a pedometer). The researcher will demonstrate how to wear the accelerometer which you will be asked to wear during waking hours on the day before the study session you will be attending.

During the study session you will be asked to complete the computer questionnaire and an interview with one of the researchers who will ask about what you had to eat and what physical activities you did the previous day. Trained researchers will also measure your height, weight and waist circumference but this is optional. We will also be holding a just-for-fun quiz with a chance to win a selection of small prizes.

After the quiz we will ask you to complete the computer questionnaire for a second time.

The online computer tool should take about 30 minutes to complete and the interviews will take about 40 minutes. Both of these will take place in a quiet room. The quiz will take about an hour and refreshments will be provided. **All participants who take part in this study will receive £15 high street shopping voucher.**

Taking part in this study is entirely voluntary and you can withdraw at any time without giving any reason and without any of your rights being affected.

All information collect during the study will be anonymised and will remain within locked filing cabinets and password protected files on computers at the University of Teesside. Only researchers working on the study will have access to the data and responses will not be discussed with any third party. Once the research is finished, the collected information will be destroyed. A summary of the results of the study will be available on request.

Study sessions

[insert study session details: time, date, location]

How to take part

If you are interested in taking part in the study, please fill in a contact form, stating which session you would like to attend and return it to researchers in one of the prepaid envelops provided. Alternatively, please contact Frances Hillier directly (contact details below). Please allow 2 working days for the contact sheet to reach the university. **Researchers must receive your details at least 3 working days before the study day.**

If you are interested in taking part in the study but are unable to attend any of the study sessions above, please also return a contact sheet and we will let you know of sessions that we are running during August 2007.

Thank you for taking time to read this information sheet.

If you have any further questions please contact:

Frances Hillier
Centre for Food, Physical Activity and Obesity,
School of Health and Social Care, University of Teesside, TS1 3BA
Tel: 01642 342757, Email: f.hillier@tees.ac.uk

Appendix O Evening Gazette article for recruitment to the test-retest and preliminary method comparison study

Volunteers needed to test new online lifestyle computer program

Researchers at the University of Teesside have developed an exciting new online computer program that collects information about diet and activities people do in their day-to-day lives and gives personalised feedback. The "Synchronised Nutrition and Activity Programme for Adults" (SNAPA) will be used in a major research study the will be run by the University of Teesside, in partnership with Middlesbrough PCT and the Gazette during 2008, to help people in the Teesside Community follow a healthier lifestyle.

It is important the computer program (SNAPA) meets the needs of the adults living in the Teesside Community. Therefore, the researchers are looking for a whole range of people to take part who are representative of people living in the area with different dietary habits and activity levels. Experience with computers is not required, as the researchers will be on hand to offer assistance and guidance where required.

People who agree to take part in the research will be given an accelerometer (a small device like a pedometer that is worn on your hip and records your activity – it will not interfere with day-to-day activity) to wear the day before attending one study session at a convenient location. At the study session participants will be asked to enter into the computer program what types of activities they did the previous day as well as what they had to eat or drink.

The study session will last approximately 3 hours and will include a break of an hour for refreshments, during which a just-for-fun trivia quiz will be held with the chance to win a selection of prizes. However, as our way of saying thank you – at the end of the study session <u>everyone</u> will receive a £15 Love2shop shopping voucher that can be used in a number of high street shops including Boots, Woolworth's, River Island, HMV, New Look, JJB and Bhs.

Study sessions will be held on the following dates and locations in Teesside:

Wednesday 25th July 2007
Middlesbrough City Learning Centre
10am-1.00pm OR 12.30pm-3.30pm

Thursday 26th July 2007
Charlbury Road Community Centre
12.30pm-3.30pm

Friday 27th July 2007
University of Teesside
10am-1.00pm OR 12.30pm-3.30pm

If you interested in taking part in the study and would like more information then please contact:

Frances Hillier (tel. 01642 342757, email: f.hillier@tees.ac.uk) or
Sarah Smith (tel. 01642 384111, sarah.smith@tees.ac.uk)
Centre for Food, Physical Activity and Obesity,
School of Health and Social Care, University of Teesside, TS1 3BA

If none of the above dates are convenient for you and are interested in taking part we will also be running more sessions during August 2007. Please contact Frances or Sarah for information.

Appendix P Consent form for test-retest and preliminary method comparison study

UNIVERSITY OF TEESSIDE

CONSENT FORM

The evaluation of an online assessment tool to measure dietary intake and physical activity behaviours in adults

ID no

	Please tick & initial	*Advocate (where applicable)*
1. I have read and understood the information sheet about this study and have had the opportunity to ask questions.	☐	☐
2. I understand that any reports from this study will not identify my individual responses or responses to comments made during the study.	☐	☐
3. I understand that all information collected during the study will be anonymised and will remain within locked filing cabinets and password protected files on computers at the University of Teesside.	☐	☐
4. I understand that participation in this study is entirely voluntary and I can withdraw at any time without giving reason and without any of my rights being affected.	☐	☐
5. I understand that by signing and returning this form, I am consenting to participate in this study.	☐	☐

Name of participant --

Participant's signature --

Advocate's signature (if applicable) ---

Researcher's signature --

Date ------------------------------

Appendix Q Accelerometer instruction sheet

UNIVERSITY OF TEESSIDE

The evaluation of an online assessment tool to measure dietary intake and physical activity behaviours in adults

Instructions for Accelerometer

ID no

The accelerometer records your physical activity; you do not need to switch it on or off. Follow the instructions below for wearing the accelerometer:

1. Place the elastic belt around your waist and the accelerometer is on the right hip under or over your clothes (whichever is most comfortable).

2. Make sure that that the arrow on the accelerometer points upwards.

3. Put the elastic through the belt buckle and pull until the belt is secure and comfortable, ensuring the monitor remains on the hip.

4. Please record the time you started to wear the accelerometer in the table below.

5. You should wear the accelerometer all day, however the accelerometers are not waterproof so must be removed when you have a bath/shower or go swimming. Please record any times that you take off the accelerometer in the table below.

6. Remove the belt and accelerometer at bedtime and record time in the table below.

Time put on at start of the day:	
Time taken off at end of the day:	
Please write any other times you took off the accelerometer during the day and how long for:	

If you have any further questions please contact Frances Hillier at:
Centre for Food, Physical Activity and Obesity, School of Health and Social Care, University of Teesside, TS1 3BA. Tel: 01642 342757, Email: f.hillier@tees.ac.uk

Appendix R 24-hour multiple pass recall dietary interview script

Key:

Italics – Spoken word
BOLD CAPITALS – Action
Normal text – clarification for researchers

INTRODUCTION

"Hi, my name is ***(insert name of Researcher)*** *and I am going to ask you what you had to eat and drink yesterday. Everything you tell me is strictly confidential and I am not interested if what you had to eat was healthy or not, we just would like to know, as accurately as possible, what you had to eat and drink yesterday. If at any stage you don't want to take part in this, that's fine, please just tell us that you want to stop.*

I am going to ask you about everything that you ate and drank yesterday, starting from the time you woke up to the time you went to bed. I will use the food atlas and some other memory aids so we can try and find out how much food or drink you had as accurately as possible."

Show some food atlas pictures

"Before we start, is there anything you would like to ask me?"

WAIT FOR RESPONSE – IF YES, ANSWER QUESTIONS, AND THEN

"Is everything clear?"

WAIT FOR RESPONSE – IF NO, CLARIFY, THEN

24 HOUR RECALL

COMPLETE ID NUMBER, DATE RECALLED, DAY OF WEEK RECALLED AND START TIME ON FORM PROVIDED

"First we are going to make a quick list of everything you ate and drank yesterday. Then we are going to go through the list adding in some detail about the foods and drinks and how much you had. At the end we will do a review just to check there isn't anything you may have forgotten."

1. **THE QUICK LIST**

"I would like you to tell us everything you had to eat and drink all day yesterday from the time you got up to the time you went to bed."

"Please include everything at home and away from home, including snacks, tea, coffee, sweets and fizzy drinks." (Give examples if needed).

"It might help you to remember what you ate or drank by thinking about where you were, whom you were with, or what you were doing yesterday. So… if you would like to start by telling me what time you got up yesterday, and the first thing that you ate or drank."

COMPLETE QUICK LIST

WHEN THE INTERVIEWEE STOPS TALKING:

"Is there anything else you can think of?"

2. **COMMONLY FORGOTTEN FOODS**

"There are some foods that people often forget about. As well as what you have already told us, did you have any:"

READ OUT COMMONLY FORGOTTEN FOODS LIST – FOLLOWS BELOW PLEASE PAUSE TO WAIT FOR ANSWER AFTER EACH LINE

"*Coffee"*
"Tea"
"Soft drinks"
"Milk"
"Biscuits"

“Cakes”
“Sweets”
“Chocolate bars”
“Other confectionery”
“Crisps”
“Peanuts”
“Other snacks”
“Sauces (like Ketchup, Salad Cream, Mayonnaise)”
“Dressings”

3. DETAILED DESCRIPTION OF FOOD AND DRINK

“Now I’m going to go through the list you have given me and ask you for some more details. If you remember anything else you had to eat or drink, please interrupt and let me know.”

3a. “Was (first item from quick list) the first thing that you had to eat/drink yesterday?”

IF YES:
- *“What time did you have this?”*
- *“Can you describe it in more detail for me?”*

PROMPT FOR DETAILS IF NECESSARY

- *“Was it a specific brand? (If required)”*
- *“How much did you have to eat / to drink?”*

(USE FOOD ATLAS PORTION SIZES, FOOD PROPS OR STANDARD UNITS, E.G. TABLE SPOON, PINT)

“Did you leave any? How much?”

(USE FOOD ATLAS PORTION SIZES, FOOD PROPS OR STANDARD UNITS, E.G. TABLE SPOON, PINT)

IF NO: “*What was the first thing you had to eat or drink yesterday?”*

MAKE A NOTE AND THEN QUESTIONS FROM 3A

3b. “Was (next item from quick list) the next thing you had to eat/drink yesterday?”

IF YES THEN QUESTIONS FROM 3A
IF NO MAKE A NOTE AND THEN QUESTIONS FROM 3A

3c. **CONTINUE UNTIL ALL FOODS ON QUICK LIST HAVE BEEN TICKED**

4. THE REVIEW

"I would like you to try and remember anything else that you had to eat or drink yesterday that you may not have already told me about."

4a. "Did you have anything to eat or drink between getting up yesterday morning and ***(insert time of first occasion)****?"*

4b. "At ***(insert time)*** *you had* ***(insert foods/drinks)****. Do you remember having anything else to eat or drink?"*

4c. "Did you have anything to eat or drink between ***(insert time)*** *and* ***(insert next time)****?"*

REPEAT 4b TO 4c UNTIL LAST TIME

4d. "At ***(insert last time)*** *you had* ***(insert foods/drinks)****. Do you remember having anything else to eat or drink?"*

4e. "Did you have anything else to eat or drink between ***(insert last time)*** *and going to bed last night?"*

5. PLACE NAMES

"Here is a card with different places on **[SHOW CARD 1].** *I would like you to choose a place name for each occasion at which you ate or drank something. I will read back to you every occasion you have told me about, for each occasion please pick a place name from the card."*

FOR EACH OCCASION / TIME ASK:

"At ***(insert time)*** *you ate/drank* ***(insert food/drinks)****, please can you tell me where you ate this?"*

SHOW CARD

RECORD 'PLACE' LETTER

WHERE PRODUCT DETAILS OR BRAND HAVE NOT BEEN RECALLED ASK TO CHECK PRODUCT AND ENTER DETAILS ON RECALL

COMPLETE '24 HOUR QUESTIONS' (attached at the end of individual record sheets)

Appendix S Example of a completed 24-hour multiple pass recall dietary interview data collection sheet

3 M.

1470601

24 HR Multiple Pass Recall - Data Collection Form

ID No. (on accerometer): 147 **Date recalled:** 14/8/07 **Day of week recalled:** Tuesday **Start time of Interview:** 12:30

Please complete the table using the 24 hr MPR Script – Sections 1-6:

✓	Quick List
✓	Cup of tea
✓	Shredded wheat
✓	Glass fruit juice
✓	Cup of coffee ✓
✓	Slice of toast
✓	Cup of tea
✓	Slice of toast
✓	Cup of tea
✓	Scone
✓	Glass ginger ale
✓	Cup of tea
✓	Quiche
✓	salad
✓	potatoes
✓	Olive oil on salad
✓	Cup of tea
	2 Glass of water

Time	Place	Description of food or drink	Brand	Amount: Code from Atlas	Amount: Unit	Leftovers	Food code	Amount (g)
8:30	A	Mug ~~Cup~~ of tea. semi skimmed milk		Q		0		
9am	A	Shredded wheat (1 biscuit) milk didn't cover				0		
		Glass fruit juice Mango and orange.	Tropicana	A		0		
10:30	A	Mug ~~Cup~~ of coffee semi skimmed milk decaffeinated	Kenco	Q				
12pm	A	Slice of toast White bread.	Homemade	I		0		
		butter	Lurpak	30/301				
		mug ~~Cup~~ of tea semi skimmed milk.	G	Q				
1:30pm	A	Slice of toast (wholemeal with maple syrup + pecan nuts)	Homemade	M		0		
		Lurpak.		304.				
	A	Mug of tea semi skimmed milk.		Q		0		

✓	Quick List	Time	Place	Description of food or drink	Brand	Amount: Code from Atlas	Amount: Unit	Leftovers	Food code	Amount (g)
		2pm	A	Scone (plain)	Homemade			0		
				Lurpak	(no sugar)	301				
		4pm	A	Glass of ginger ale		L		0		
		5pm	A	Mug of tea Semi skimmed milk		Q				
		6:30	A	Quiche (1/4) (100g) of Lorraine	Sainsbury's own			0		
				Salad - lettuce (watercress rocket spinach) ~~Potatoes~~ with extra virgin olive oil	x 2 portions	(drizzle)				
				2 new potatoes with skins on						
				3 cherry Tomatoes						
			A	Apple pie (1)	Mr Kipling			0		
		7pm	A	Mug of tea Semi skimmed milk		Q		0		
		10:30pm	A	2 glasses water (pints)				0		

✓	Quick List

Time	Place	Description of food or drink	Brand	Amount		Leftovers
				Code from Atlas	Unit	

Food code	Amount (g)

Check list:

	Ring one
Did you use the **forgotten foods** list (item 3 of protocol)?	Yes / No
Did you **review** the day's food after completing the detailed record (item 5 of protocol)?	Yes / No
Have you **asked the respondent** to give you a **place** name for each eating occasion (item 6 of protocol)?	Yes / No
Have you **checked the respondent's** food store for any missing **brand** names (item 7 of protocol)?	Yes / No

24-HOUR QUESTIONS

1. Please look at Card 2 and tell me if yesterday you had any of the dietary supplements listed whether in tablets, capsules or liquid form. Yes / No

If Yes, please record below

Supplement number (from card)	Name of supplement	Brand of supplement	Strength of supplement (if applicable)	Number of units taken*

* Unit may be a tablet, capsule or spoonful

2. Did you have any plain drinking water yesterday, either from a tap or bottle, that you have not already mentioned (including water taken with medicines)?

☐1 Yes ***(RECORD ON FOOD CONSUMPTION RECORD)***

☑2 No

3a. Was the amount of food that you had yesterday about what you usually have, less than usual, or more than usual?

- ☐ 1 Usual amount *(GO TO QUESTION 4a)*
- ☑ 2 Less than usual *(GO TO QUESTION 3b)*
- ☐ 3 More than usual *(GO TO QUESTION 3c)*
- ☐ 4 Don't know *(GO TO QUESTION 4a)*

3b. What is the main reason that the amount you had to eat yesterday was **<u>less than usual</u>**?

CODE ONLY ONE. DO NOT PROMPT FOR RESPONSE

- ☑ 1 Sickness
- ☐ 2 Short of money
- ☐ 3 Little food in the house
- ☐ 4 Travelling
- ☐ 5 At a special occasion or on holiday
- ☐ 6 On a special day
- ☐ 7 Weekend day
- ☐ 8 Too busy
- ☐ 9 Not hungry
- ☐ 10 Dieting
- ☐ 11 Fasting
- ☐ 12 Bored or stressed
- ☐ 13 Working shifts
- ☐ 14 Don't know
- ☐ 15 Some other reason (specify)

Loss of Appetite

(GO TO QUESTION 4a)

3c. What is the main reason that the amount you had to eat yesterday was **<u>more than usual?</u>**

CODE ONLY ONE. DO NOT PROMPT FOR RESPONSE

- ☐ 1 Just got some money
- ☐ 2 Travelling
- ☐ 3 At a special occasion or on holiday
- ☐ 4 On a special day
- ☐ 5 Weekend day
- ☐ 6 Very hungry
- ☐ 7 Bored or stressed
- ☐ 8 Working shifts
- ☐ 9 Don't know
- ☐ 10 Some other reason (specify)

____

4a. Was the amount of drink that you had yesterday about what you usually have, less than usual, or more than usual?

- ☐ 1 Usual amount ***(GO TO QUESTION 5)***
- ☐ 2 Less than usual ***(GO TO QUESTION 4b)***
- ☑ 3 More than usual ***(GO TO QUESTION 4c)***
- ☐ 4 Don't know ***(GO TO QUESTION 5)***

4b. What is the main reason that the amount you had to drink yesterday was **<u>less than usual?</u>**

CODE ONLY ONE. DO NOT PROMPT FOR RESPONSE

- ☑ 1 Sickness
- ☐ 2 Short of money
- ☐ 3 Little food in the house
- ☐ 4 Travelling
- ☐ 5 At a special occasion or on holiday
- ☐ 6 On a special day
- ☐ 7 Weekend day
- ☐ 8 Too busy
- ☐ 9 Not thirsty
- ☐ 10 Dieting
- ☐ 11 Fasting
- ☐ 12 Bored or stressed
- ☐ 13 Working shifts
- ☐ 14 Don't know
- ☐ 15 Some other reason (specify)

Recovering

(GO TO QUESTION 5)

4c. What is the main reason that the amount you had to drink yesterday was **more than usual?**

CODE ONLY ONE. DO NOT PROMPT FOR RESPONSE

- ☐1 Just got some money
- ☐2 Travelling
- ☐3 At a special occasion or on holiday
- ☐4 On a special day
- ☐5 Weekend day
- ☐6 Very thirsty
- ☐7 Bored or stressed
- ☐8 Working shifts
- ☐9 Don't know
- ☐10 Some other reason (specify) ____________________

5. Who else was present during the interview?

CODE RELATIONSHIP TO RESPONDENT (i.e. person about whom recall is being conducted). CODE ALL THAT APPLY

- ☑1 **NO ONE ELSE PRESENT**
- ☐2 **SPOUSE/PARTNER**
- ☐3 **CHILDREN**
- ☐4 **PARENT/CARER**
- ☐5 **OTHER FAMILY MEMBERS**
- ☐6 **VISITORS**
- ☐7 **OTHER (specify)** ____________________

TIME AT WHICH INTERVIEW FINISHED 12:50

Appendix T Ethical approval for internet strand of the Get a Better Life campaign

Dean: Professor Paul Keane
SCHOOL OF HEALTH & SOCIAL CARE

Providing **Opportunities** - Pursuing **Excellence**

UNIVERSITY OF TEESSIDE

PRIVATE AND CONFIDENTIAL

Direct Line: 01642 342750

14th December 2007

Carolyn Summerbell
School of Health & Social Care
University of Teesside

Dear Carolyn

209/07 – An evaluation of a population health initiative (Get a Better Life) aimed at improving dietary and physical activity behaviours in adults living in the Tees Valley Researcher: Alisha Crayton, Sean Crooks, David Cumbor, Frances Hillier Supervisor: Carolyn Summerbell

Decision: Approved

Thank you for your application to the School of Health & Social Care Research Governance and Ethics Committee.

The Committee reviewed and approved your application on 11th December 2007 and your study may proceed as it was described in your application pack.

Please note:

> Where applicable, your study may only proceed when you have also received written approval from any other ethical committee (e.g. NRES) and operational / management structures relevant (e.g. Local NHS R&D). If applicable please forward to me a copy of the approval letter from NRES before proceeding with the study.
>
> In all cases, should you wish to make any substantial amendment to the protocol detailed, or supporting documentation included, in your approved application pack (other than those required as urgent safety measures) you must notify the Committee (and all other relevant bodies) prior to implementing any amendment.

Professor Carolyn Summerbell
Assistant Dean
INSTITUTE OF HEALTH SCIENCES & SOCIAL CARE RESEARCH
UNIVERSITY OF TEESSIDE MIDDLESBROUGH
TEES VALLEY TS1 3BA UK
TEL: +44 (0)1642 342750 FAX: +44 (0)1642 342961
www.tees.ac.uk

INVESTOR IN PEOPLE

POSITIVE ABOUT DISABLED PEOPLE

VAT REG NO. GB 686 4809 81

The applicants are commended on a very well written application with complete and comprehensive supplementary paperwork.

On behalf of the School of Health & Social Care Research Ethics Committee please accept my best wishes for success in completing your study.

Please inform the Committee when the study has been completed.

Yours sincerely

pp

Dr. Alasdair MacSween

Chair
Research Ethics Committee
School of Health & Social Care

Appendix U Ethical approval for the community strand of the Get a Better Life campaign

Dean: Professor Paul Keane
SCHOOL OF HEALTH & SOCIAL CARE

Providing **Opportunities** - Pursuing **Excellence**

UNIVERSITY OF TEESSIDE

PRIVATE AND CONFIDENTIAL

Direct Line: 01642 342750

19th November 2007

Carolyn Summerbell
School of Health & Social Care
University of Teesside

Dear Carolyn

Study 153/07 – The Effectiveness of a community challenge to promote healthy diets and levels of physical activity Researcher: Frances Hillier Supervisor: Carolyn Summerbell

Thank you for submitting the amendments to the above proposal. I can confirm that through Chair's action the study can now proceed.

Please forward me a copy of the approval letter from the Local Research Ethics Committee before proceeding with the study.

The School of Health & Social Care Research Ethics Committee wish you well with your study.

Yours sincerely

pp **Dr. Alasdair MacSween**
Chair
Research Ethics Committee
School of Health & Social Care

Professor Carolyn Summerbell
Assistant Dean
INSTITUTE OF HEALTH SCIENCES & SOCIAL CARE RESEARCH
UNIVERSITY OF TEESSIDE MIDDLESBROUGH
TEES VALLEY TS1 3BA UK
TEL: +44 (0)1642 342750 FAX: +44 (0)1642 342961
www.tees.ac.uk

Appendix V Durham University ethical approval email correspondence

HILLIER F.

From: SCOTT E.M.
Sent: 20 October 2008 10:04
To: SUMMERBELL C.D.
Cc: HILLIER F.; MOORE H.
Subject: RE: Ethics

Thanks, Sorry but I haven't any free time this week.

However, as a first action, can you let me have the list of projects with their status as requested in my previousl email. I'll then know what we're dealing with.

I don't think there's any point in us doing an ethics review of projects that have already been approved at Teesside and are up and running. I think the important points for those studies is to ensure they're registered with the School Research Committee (via James Mason and Andrew Watt) and ensure that your indemnities etc are still valid from Durham perspective. They will also need to know the status of you and your team related to the Research Passport for any studies being carried out in NHS.

For any new studies the School Ethics will consider in the normal way and we have a system whereby we approve first before submission to either NHS organisation or to NRES.

Hope this all helps. Best wishes.

Dr Eileen M Scott RGN, BA(Hons), M.Litt, PhD
Post-doctoral Research Fellow & Life Cycle Strand Leader - Phase One Medicine,
School of Medicine and Health,
Wolfson Research Institute,
Durham University Queen's Campus,
Stockton-on-Tees, TS17 6BH

Telephone 0191 33 40428 eileen.scott@durham.ac.uk
http://www.dur.ac.uk/wolfson.institute/fellowships/details/?id=2619

HILLIER F.

From:	Pearson, Stephen [Stephen.Pearson@durham.ac.uk]
Sent:	16 January 2009 15:36
To:	HILLIER F.
Subject:	RE: Insurance query - F. Hillier - Community Challenge Project
Attachments:	EL & PL 08-09.pdf

Dear Frances,

Thank you for your e-mail of 15 January 2009.

I have made some enquires with our insurers and they have confirmed to me that they will provide cover for this research work by the university's insurance arrangements.

Durham University's legal liability covers will therefore operate as per usual for the research team from the University involved in this project (transferred from Teesside University).

I have enclosed a copy of Durham University's `To whom it may concern` letter for the liability covers which I hope this is helpful for you.

Best regards,
Steve.

Stephen Pearson
Insurance Officer

Appendix W Consent form for the community strand of the 'Get a Better Life' campaign

CONSENT FORM

Please initial boxes

1. I confirm that I have read and understood the 'participant information sheet' for the above study and I had the opportunity to ask questions

2. I understand that my participation is entirely voluntary and that up to commencement of data analysis in November 2009, I am free to withdraw my participation from this study at any time without giving a reason and without the care I receive or my legal rights being affected.

3. All the information about your participation in this study will be kept strictly confidential and anonymised with an identification number linked to your name.

4. All information about your participation will be stored and locked in a filing cabinet. Computerised information will be stored on password protected computers at the University of Teesside. Only researchers from the University of Teesside working on this project will have access to this information, which will be securely destroyed after the research has been completed.

5. I agree to take part in this study

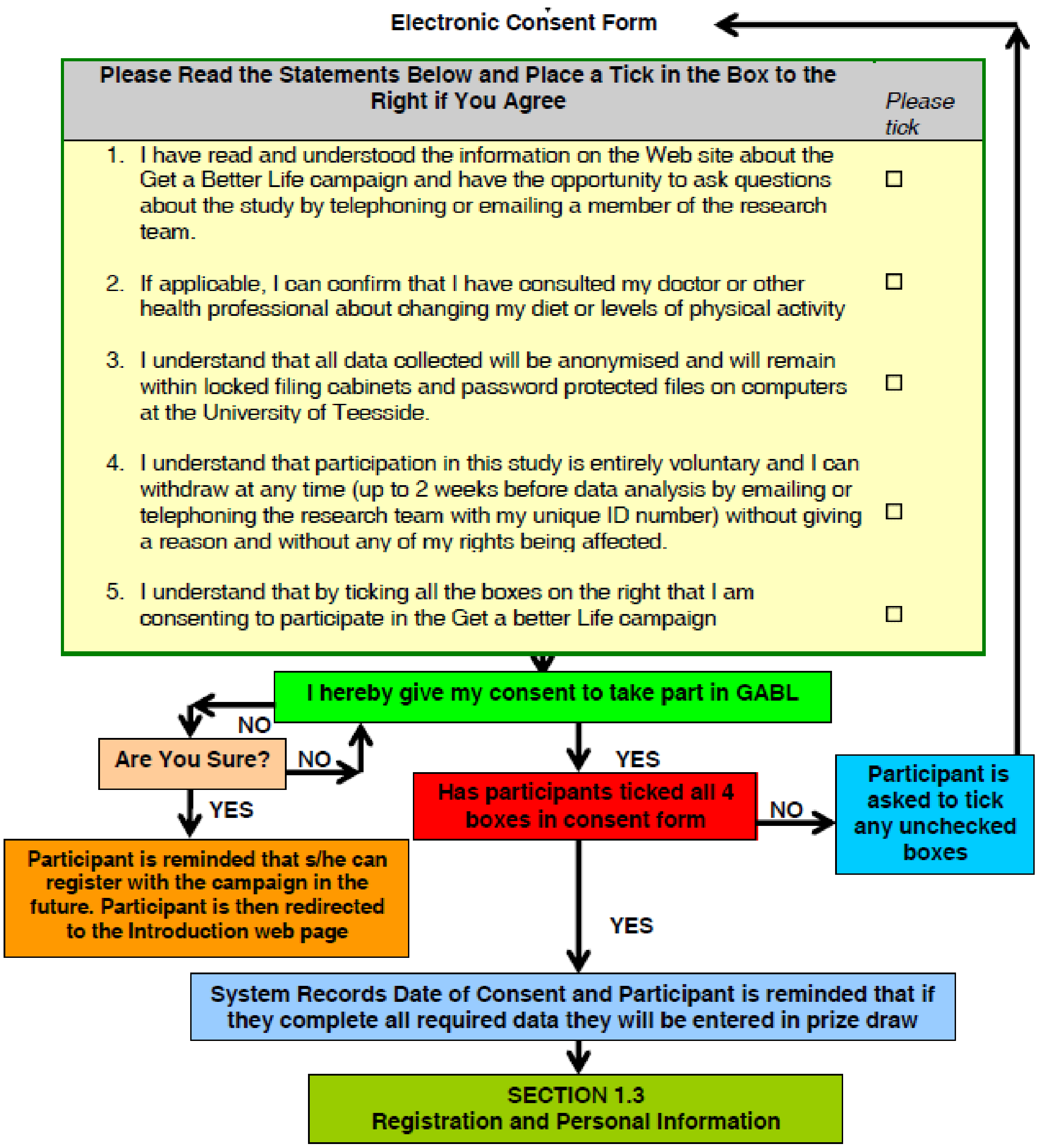
Name of Participant……………………………. Date ………..

Signature of Participant…………………………………………

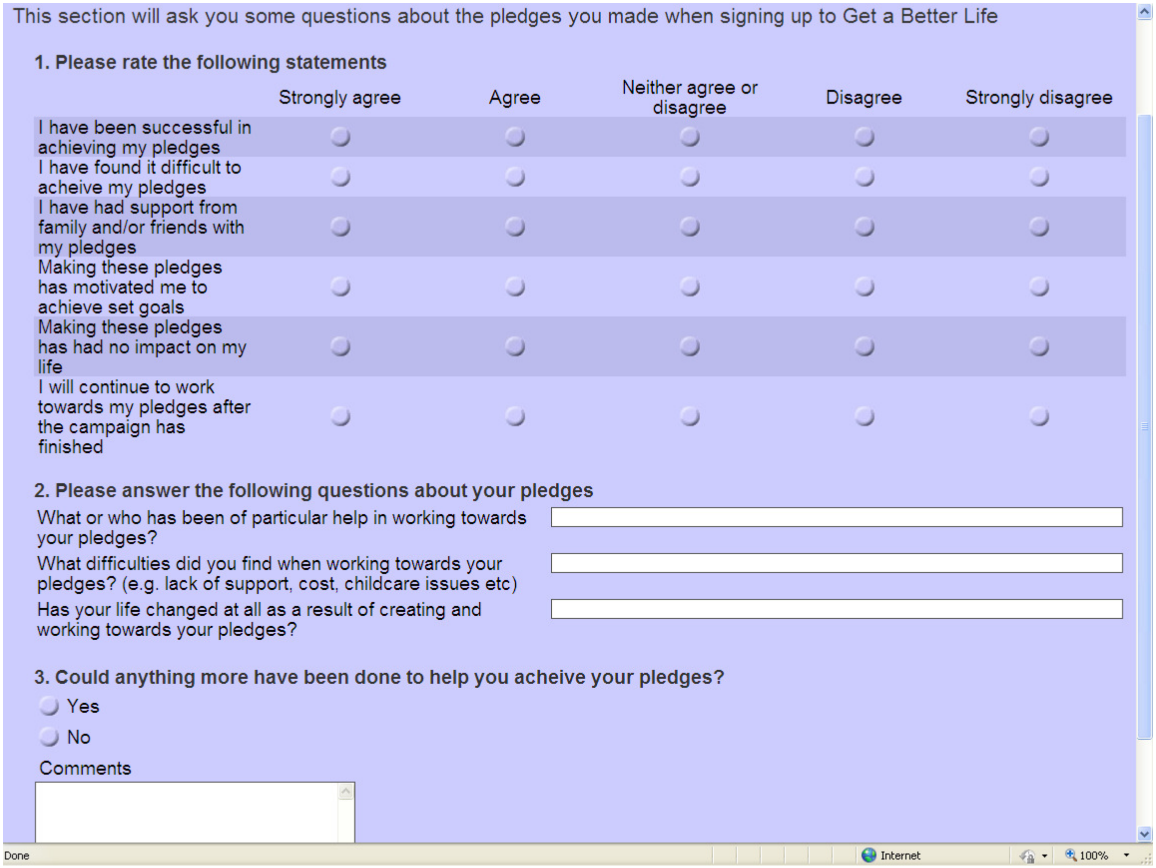
Name of Researcher……………………………. Date ………..

Signature of Researcher…………………………………………

Appendix X E-consent form for internet strand of the ‘Get a Better Life’ campaign



Appendix Y Feedback questionnaire for the internet strand of the 'Get a Better Life' campaign



This section will ask you some questions about the pledges you made when signing up to Get a Better Life

1. Please rate the following statements

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
I have been successful in achieving my pledges					
I have found it difficult to acheive my pledges					
I have had support from family and/or friends with my pledges					
Making these pledges has motivated me to achieve set goals					
Making these pledges has had no impact on my life					
I will continue to work towards my pledges after the campaign has finished					

2. Please answer the following questions about your pledges

What or who has been of particular help in working towards your pledges?

What difficulties did you find when working towards your pledges? (e.g. lack of support, cost, childcare issues etc)

Has your life changed at all as a result of creating and working towards your pledges?

3. Could anything more have been done to help you acheive your pledges?

Yes

No

Comments

Done Internet 100%

Get a Better Life **Exit this survey**

Get a Better Life Website

50%

This section will ask you some questions about the Get a Better Life website

4. Approximately how many times did you visit the Get a Better Life website?

- Only to sign-up and complete data collection
- 3-5 times
- 5-10 times
- 10-15 times
- 15+ times

5. Please rate the following statements

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The information on the website was easy to find					
There was enough information on the website					
The information on the website was not useful in helping me achieve my pledges					

6. How do you think the website could be improved?

Done Internet 100%

Get a Better Life **Exit this survey**

Synchronised Nutrition and Activity Program (SNAPA)

67%

This section will ask you some questions about the Synchronised Nutrition and Activity Program which was used to collect diet and physical activity data.

7. Did you find SNAPA easy to use?

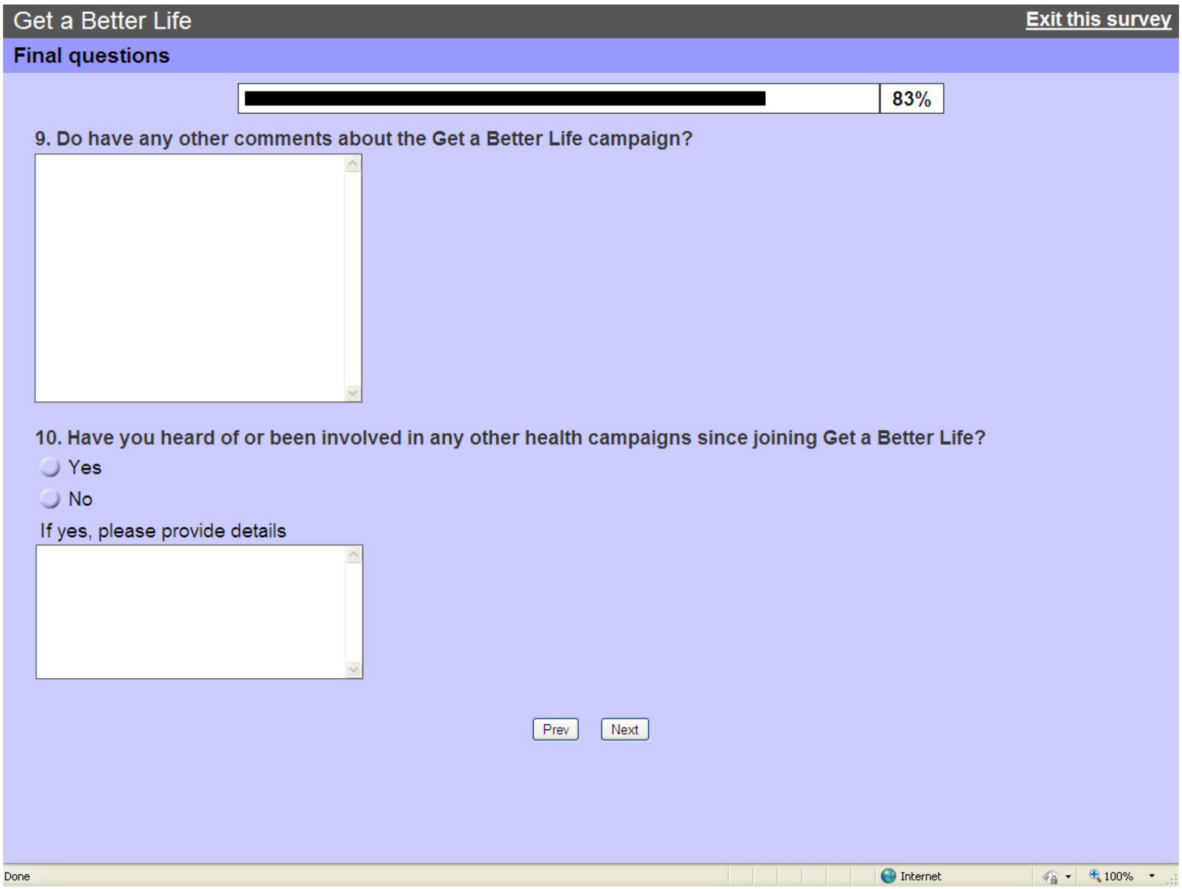
- Yes
- No

Do you have any comments on the user friendliness of SNAPA?

8. How do you think SNAPA could be improved?

Prev Next

Done Internet 100%



Get a Better Life
Exit this survey

Final questions

83%

9. Do have any other comments about the Get a Better Life campaign?

10. Have you heard of or been involved in any other health campaigns since joining Get a Better Life?

- Yes
- No

If yes, please provide details

Prev Next

Done Internet 100%

Appendix Z Ethical approval for the primary method comparison study

Inspiring success

Teesside University

PRIVATE AND CONFIDENTIAL

Direct Line: 01642 342750

2nd February 2009

Alan Batterham
School of Health & Social Care
University of Teesside

Dear Alan

Study 265/08 – Patterns of Eating and Activity Study 111 (PEAS 111): Accurate and precise measurement of energy balance behaviours, including physical activity energy expenditure and energy intake, using a variety of objective and subjective techniques in adults Researcher: Frances Hillier, Claire Pedley, Alisha Crayton, Catherine Nixon Supervisor: Alan Batterham.

Decision: Approved

Thank you for submitting an amended application pack. I am pleased to confirm that the comments raised by the School of Health & Social Care Research Governance and Ethics Committee have been addressed in your amended application pack and your study has been approved through Chair's Action. Your study may proceed as it was described in your approved application pack.

Please note:

Where applicable, your study may only proceed when you have also received written approval from any other ethical committee (e.g. NRES) and operational / management structures relevant (e.g. Local NHS R&D). A copy of this approval letter **must** be attached to applications to any other ethical committee. If applicable please forward to me a copy of the approval letter from NRES before proceeding with the study.

School of Health & Social Care

Inspiring success

Teesside University

In all cases, should you wish to make any substantial amendment to the protocol detailed, or supporting documentation included, in your approved application pack (other than those required as urgent safety measures) you must obtain written approval for those, from myself and all other relevant bodies, prior to implementing any amendment. Details of any changes made as urgent safety measures must be provided in writing to myself and all other relevant bodies as soon as possible after the relevant event; the study should not continue until written approval for those changes has been obtained from myself and all other relevant bodies.

On behalf of the School of Health & Social Care Research Governance and Ethics Committee please accept my best wishes for success in completing your study.

Yours sincerely

pp **Dr. Alasdair MacSween**
Chair
Research Governance and Ethics Committee
School of Health & Social Care

School of Health & Social Care

Appendix AA Durham University ethical approval email correspondence

HILLIER F.

From:	PERRETT R.
Sent:	31 March 2009 16:14
To:	HILLIER F.
Cc:	MACFADYEN J.M.; WATT A.
Subject:	FW: Ethics approval
Attachments:	RE: Ethics; RE: PEAS III; RE: Approved 265/08 PEAS III; PEAS III Protocol.doc

Dear Frances,

I have had a look through your proposal, and the emails that were attached, and I agree with Eileen's email that I see no problem with study's taking place without going through the full Durham SMH ethical approval process, if they already has been through the process at Teeside and are up and running.

James has reviewed the proposal and is happy with it from a research perspective, but per Eileens email, Andrew will need confirmation re indemnity arrangements before you continue the study from Durham and to ensure the project is properly registered with SMH and the University. I have copied both him and Judith in to this email to ensure they are aware of the project.

If you have any further questions please don't hesitate to contact me. I am away for a few days from tomorrow but return to the office next monday (6th).

Best wishes
Rebecca

Rebecca Perrett
R&D Manager
Wolfson Research Institute
Durham University
Queens Campus
Stockton-on-Tees
TS17 6BH

HILLIER F.

From:	WATT A.
Sent:	02 April 2009 08:01
To:	HILLIER F.
Subject:	RE: Ethics approval

Frances,

I don't think we need to involve the insurance section unless your project is being directed by any Teesside staff. We have a contract in place with the Community Challenge sponsor so all the indemnity requirements are in place.

I understood from Rebecca that Carolyn is your PhD supervisor - if this is not the case could let me know who is.

Andrew

Appendix BB Invitation letter to workplace representatives for the primary method comparison study

Dear [insert name]

I am writing to invite your workplace/college/university* to take part in a study being run by the University of Teesside. The Patterns of Eating and Activity Study III (PEAS III) aims to investigate physical activity levels and eating patterns of adults living in the Tees Valley using different assessment methods. The results of the study may contribute to the understanding of people's lifestyles, particularly their levels of physical activity and diets, which is essential for designing relevant policies and effective programmes, which will aid the design of more effective health interventions, such as, the prevention of obesity.

I have enclosed a study protocol and participant information sheet which provides more detail about the study. If you are happy to take part in this study, you will be asked to distribute posters and emails (provided by the research team) to staff/students* inviting them to take part in the study. Exact logistics of how the study will be carried out in your workplace/college/university* will be discussed with the research team, however in summary, during the study the research team will require:

- The use of a private room where measurements (height, weight, waist circumference) can be taken, monitors set up and the step test carried out
- Access to work/college/university canteen/eating area during lunchtime for the purpose of the diet observation
- Internet access for participants for the completion of the online assessment tool

If you are interested in taking part or have any questions about the study, please contact the PEAS III research team.

Best wishes

Frances Hillier

PEAS III Project Team,
School of Health and Social Care,
University of Teesside,
Middlesbrough, TS1 3BA

☎ 0191 3340456 ✉ f6095602@tees.ac.uk

Appendix CC Participant information sheet for primary method comparison study

ADULT INFORMATION SHEET
PEAS III – Patterns of Eating and Activity Study III

The PEAS III research team from the University of Teesside want to find out about physical activity levels and eating patterns of adults living in the Tees Valley. They have also developed a web-based program that collects data on physical activity levels and eating patterns and want to test the program against precise methods of the diet and physical activity assessment. This information sheet will help you to decide whether you would like to take part in this project.

What is the purpose of the study?
In this project we are going to try to measure energy balance behaviours, (physical activity energy expenditure and dietary energy intake), using different kinds of methods in adults.

Who will be taking part?
Approximately 80 adults (aged 16 years or above) will be invited to participate in the study. You will be unable to take part in the study if you have any symptoms or known presence of cardiovascular, pulmonary or metabolic disease; if you are pregnant; if you have musculoskeletal problems; or have any allergies to plasters. You will also be asked to obtain approval from your GP to take part in the study if you are male and over 44 years, female and over 54 years and/or you have 2 or more risk factors for cardiovascular (CV) disease (family history, smoking, obesity, high blood pressure, sedentary lifestyle). You will be asked to complete a health screening questionnaire with the researcher before the study to identify any major risk factors.

When will this project run?
The project will run between March and October 2009.

How will this be done?

Assessments at workplace/college

a. **Physical activity monitors:** We will be asking you to wear two monitors for 11 days (Friday, week 1 to Monday, week 3) which will measure your physical activity levels. The first monitor is a small accelerometer unit worn on a belt around the hip (Actigraph). The second monitor is a small combined heart rate and accelerometer which is secured to the skin by two sticky electrodes on the chest (Actiheart). Actihearts will be fitted in a private room by female researchers. Please note that the Actiheart monitor is not a clinically diagnostic tool so will be unable to detect any undiagnosed (or diagnosed) heart conditions.
b. **Online assessment program:** During the same period, you will be asked to complete the web-based program on five days, (Monday to Friday, week 2) which will ask questions relating to what you ate/drank and what physical activities you did during the previous day.

- **c. Dietary observation:** Over the same period, you will be observed by researchers who will record exactly what you eat during four lunchtimes (Monday to Thursday, week 2).
- **d. Step tests:** You will be asked to carry out a step test (Monday, week 3). The step test involves 8 minutes of stepping up and down a step, starting at 15 steps for the first minute (1 step = up, up, down, down) and increasing to 33 steps per minute (intensity ranges from the equivalent of a brisk walk to a slow jog), which is then followed by two minutes of recovery.
- **e. Anthropometric measurements**: Your height, weight and waist circumference will be individually measured and recorded anonymously.
- **f. Feedback questionnaire**: You will be asked to complete a questionnaire about your views on the online assessment program for its continued improvement. This questionnaire will be completely anonymous.

Informed consent and confidentiality

It is up to you to decide whether or not you want to take part. If you decide to take part then you will be assigned an ID number. You can withdraw from the study at any time without giving a reason up to 1st November 2009 by contacting the researchers (contact details below) and quoting your ID number. If you agree to take part, all the information that we collect from you will be kept strictly confidential, and you will not be identified in any reports or publications.

What are the possible benefits of taking part?

The information gained from this study will help to improve our understanding of adults' eating patterns and levels of physical activity and the assessment of these behaviours.

All participants who complete the study will receive £30 worth of shopping vouchers.

What are the possible risks of taking part?

1. Adhesive acrylic allergy: preparation of the skin is essential to obtaining accurate heart rate data from the Actihearts, this is achieved by cleaning the skin and then, through gentle abrasion, the removal of the layer of dead skin, which results in minimal skin damage or irritation. The electrodes are attached to the skin by two plasters, and so anyone with a known adhesive acrylic allergy will not be allowed to participate in this study. If the plasters make your skin hot or itchy please removed these immediately and inform the research team.

2. The step test involves moderate to vigorous physical activity; it is a 'submaximal' test meaning that you are not required to exercise to your maximum or to exhaustion. The risk involved in such a test for apparently healthy people is very low. However, as a precaution, it is advised that males over 44 years and females over 54 years and/or anyone with 2 or more risk factors for CV disease (family history, smoking, obesity, high blood pressure, sedentary lifestyle) gain medical approval from their GP before taking part in the study. Any of the above factors will be identified during a pre-study meeting with one of the research team. During the step test, you will be observed closely and if you or the researcher has any concerns the test will be terminated immediately.

3. Drawing attention to issues surrounding eating, physical activity and body weight, for some participants, could be uncomfortable. We will make available leaflets and advice points available for those who would want to seek expertise over these matters.

Safe storage of information

All information collected as part of this study will be stored in accordance with the Data Protection Acts (1984, 1998). Access to the study materials and data, while the study is underway, will be restricted to members of the research team. Any notes taken and/or any paper based materials you may give us will be stored in a locked filing cabinet for the length of the project, and/or stored electronically on password protected computers at the University of Teesside. After the project is completed all the study materials and information will be stored securely for up to six years by the University of Teesside and then destroyed.

Who will see this information?

All participants and their workplace/college/university will receive a full written summary of the findings of the study. If you wish to receive feedback on your own individual data please contact the researchers (contact details below). The findings of the study may also be printed in journals and talked about at conferences. Your name will not be identified in any report or journal article.

How do I take part?

If you would like to take part in the study, please contact the research team (details below) who will arrange a pre-study meeting with you.

Thank you for reading through this information.

If you have any further questions, you may contact the research team:
PEAS III Project Team,
School of Health and Social Care,
University of Teesside,
Middlesbrough,
TS1 3BA
☎ 0191 3340456
✉ f6095602@tees.ac.uk

Appendix DD Consent form for primary method comparison study

CONSENT FORM

PEAS III – Patterns of Eating and Activity Study III

Please initial box if you agree

I have read and understood the information sheet provided for the above study and have had the opportunity to ask questions about the study.	
I understand that participation in this study is entirely voluntary and I can withdraw at any time prior to data analysis (1st November 2009) without giving any reason and without any of my rights being affected.	
I understand that all information will be treated as confidential, and that I will not be identified in any way.	
I understand that all hard copies of data collected will be stored in a locked filing cabinet in the office where the lead researcher is based at Durham University, and any electronic files will be stored on password protected computers and all raw data will be destroyed once the study and subsequent analyses are completed.	
I do not have any known allergies to plasters (also known as adhesive acrylic allergy).	
I understand that only female researchers will be carrying out any measurements involved in this study	
I have completed the pre-participation screening questionnaire with a researcher and, if required, gained medical approval from my GP.	
I agree to participate in this project.	

Name of Participant:

Participant Signature: Date:

Appendix EE Instructions for the Actiheart® and Actigraph™ monitors and diary sheet

<u>Actiheart and Actigraph instructions</u>
<u>PEAS III – Patterns of Eating and Activity Study III</u>

The Actiheart and Actigraph monitors are set to record activity; you do not need to switch it on or off. Follow the instructions below for wearing the Actiheart and Actigraph:

Actiheart

- Your skin will be prepared by the researcher by:
    - Cleaning the skin to ensure that it is clean and oil free using a wipe
    - Rubbing the surface of the skin with the back of the electrode (Cardioprep® pads) to remove the top layer of skin (some redness may be seen and this is normal and should not be cause for concern)
- The electrodes and Actiheart monitor will be placed as in Figure 1 by the researcher

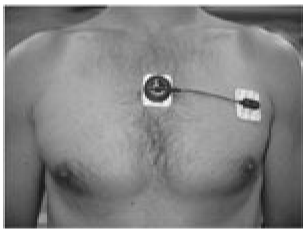


Figure 1. Horizontal placement of the Actiheart (in the higher chest position)

- Once the Actiheart is setup, wear the Actiheart for 11 days continuously (DO NOT to remove when sleeping or doing water based activities, for example showering or swimming)
- If at any time the Actiheart becomes unattached from the electrodes, please re-attach. The researcher will demonstrate how to do this.
- Electrodes can be removed and replaced if required (spare electrodes provided). The researcher will demonstrate how to do this.
- If you do suffer an allergic reaction from the electrodes please remove them immediately and inform the research team (contact details below)

Actigraph

- Place the elastic belt around your waist, so that the buckle is at the front and the accelerometer is on the right hip under your clothes, and against your skin.
- Make sure that that the arrow on the accelerometer points upwards with the serial number on the bottom.
- You should wear the accelerometer during waking hours (putting on first thing in the morning and taking off before you go to bed) for 11 days, however the accelerometers are not waterproof so must be removed when you do any water based activities, for example showering or swimming.

***PEAS III Project Team,** School of Health and Social Care**,** University of Teesside, Middlesbrough, TS1 3BA ☎ 0191 3340456 ✉ f6095602@tees.ac.uk*

Monitor removed (Actiheart or Actigraph)	Date	Time removed	Time reattached

Appendix FF Pre-participation screening questionnaire

PEAS III: Pre-participation screening questionnaire
(to be completed by researcher)

Risk factor	Criteria	Yes/No	Notes
Age	*Man older than 44 years Woman older than 54 years*		
Family history	*Close blood relative had heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister)*		
Smoking	*Current or quit in last 6 months*		
High blood pressure	*≥140/≥90*		
Obesity	*Waist girth >102cm (men) >88cm (women)*		
Sedentary lifestyle	*<30 minutes of physical activity on at least 3 days per week*		
Symptoms			
Experience chest discomfort with exertion			
Experience unreasonable breathlessness			
Experience dizziness, fainting or blackouts			
Take heart medications			
Other health issues			
Diabetes			
Asthma or other lung disease			
Musculoskeletal problems that limit physical activity			
Pregnant			

Outcome of screening questionnaire (please tick ***one*** *option):*

Eligible for inclusion	
Eligible for inclusion with GP clearance	
Not eligible for inclusion	

Researcher notes

GP clearance required if:	*Exclude if:*
Male >44 years or female >54 years AND/OR ≥2 risk factors	*≥1 symptom or health issue*

Signature of researcher ……………………………………… Date …………………

Appendix GG Lunchtime observation standard operating procedure

Patterns of Eating and Activity Study (PEAS) III
Standing Operating Procedures in Workplaces

DIRECT OBSERVATION

1 Introduction

- Observation of what participants eat and drink will take place during a work lunchtime
- Direct observation is the gold standard for energy intake assessment.

2 Responsibility

- Researchers — To oversee and monitor what is eaten at lunchtime including portion size and eating behaviour (i.e. swapping food and drinks)
  To ensure ID numbers are consistent with participant

3 Equipment

- Recording sheets
- Pens

4 Procedure

- Researcher will be provided with a list of participants with their ID numbers
- Researchers will be placed in a workplace eating area to monitor the following:

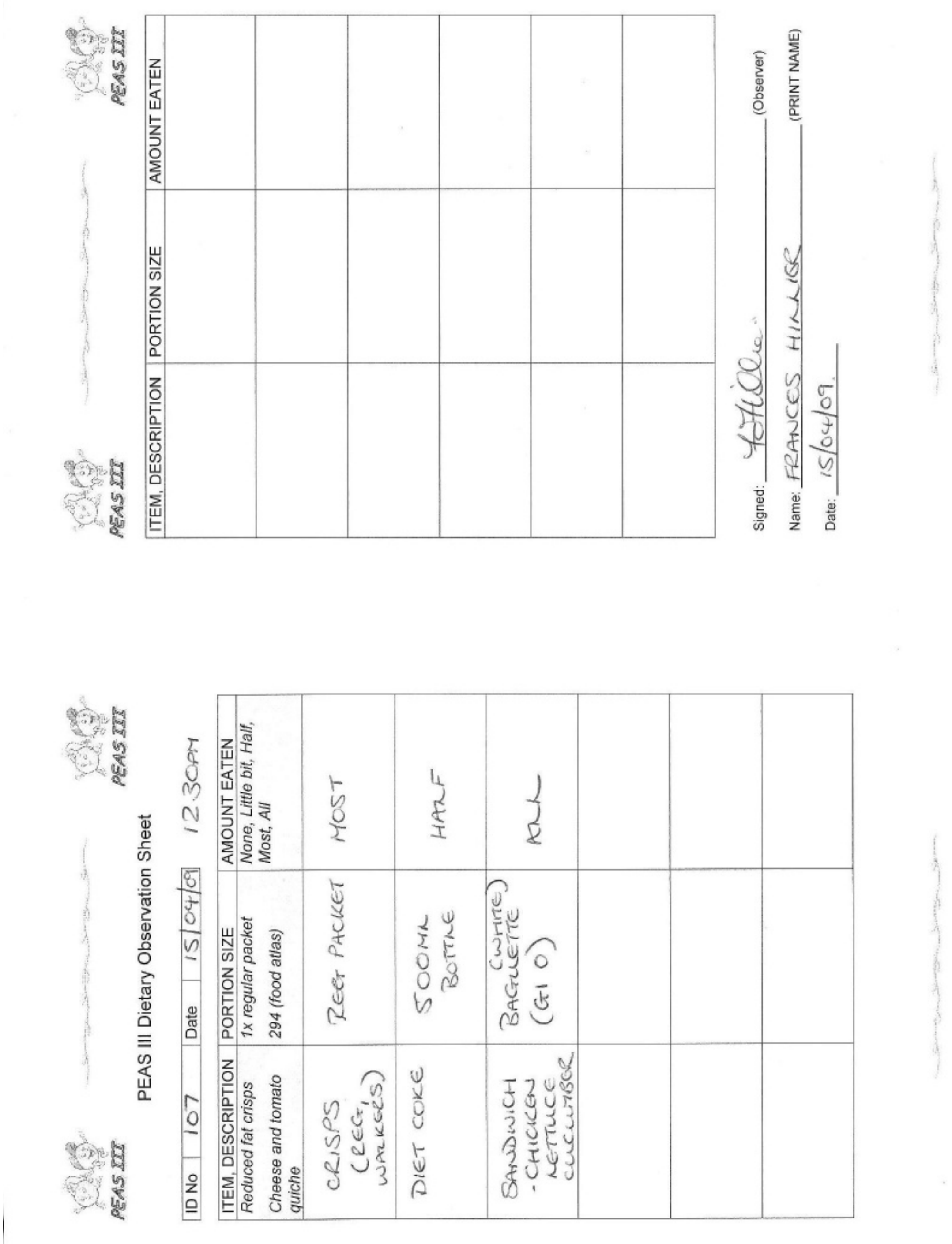
  - One researcher observes a *maximum* of four participants.

  - Observation is related to the consumption of their lunch recording exactly what has been eaten and/or drunk

  - One recording sheet is required per participant and need to record (in clear writing):
    a) a description of each food/beverage item (packet of crisps, pasta salad, tomatoes, orange juice, water *etc* – paying particular attention to reduced fat/calorie options)
    b) estimation of portion size using standard packet sizes and food atlas
    c) whether the participant ate all, most (approx ¾), half, little bit (approx ¼) or none.

  - At the end of the session, the researcher must sign and date each of their forms and pass back to the lead researcher for transcription

Appendix HH Example of a completed lunchtime dietary observation data collection sheet



PEAS III Dietary Observation Sheet

ID No	107	Date	15/04/09	12.30PM

ITEM, DESCRIPTION	PORTION SIZE	AMOUNT EATEN
Reduced fat crisps *Cheese and tomato quiche*	*1x regular packet* *294 (food atlas)*	*None, Little bit, Half, Most, All*
CRISPS (REG, WALKERS)	REG PACKET	MOST
DIET COKE	500ML BOTTLE	HALF
SANDWICH - CHICKEN LETTUCE CUCUMBER	BAGUETTE (WHITE) (G10)	ALL

ITEM, DESCRIPTION	PORTION SIZE	AMOUNT EATEN

Signed: ______ (Observer)

Name: FRANCES HILLIER (PRINT NAME)

Date: 15/04/09

Appendix II Feedback questionnaire for the primary method comparison study

Patterns of Eating and Activity Study (PEAS) III Exit this survey

1. Please rate the assessment methods used in this study (1 = favourite, 4 = least favourite)

	1	2	3	4
Actiheart monitor (attached to electrodes)				
Actigraph monitor (attached to belt)				
Lunchtime observation				
The Synchronised Nutrition and Activity Program for Adults (SNAPA)				

2. What were the good and bad things about using the Actiheart monitors?

3. What were the good and bad things about using the Actigraph monitors?

4. What were the good and bad things about the lunchtime observations?

Done Internet 100%

5. What were the good and bad things about using the Synchronised Nutrition and Activity Program for Adults (SNAPA)?

6. Approximately how long did it take you to complete SNAPA, on average?

7. Please add any suggestions for the improvement of SNAPA

8. Did you find your individual feedback useful?

Yes

No

Comments

Internet 100%

8. Did you find your individual feedback useful?

- Yes
- No

Comments

9. How often do you use the following:

	At least once a day	At least once a week	At least once a month	Less than once a month
Computer/laptop for creating documents in programs such as Word, Excel, Access etc (for work)				
Computer/laptop for creating documents in programs such as Word, Excel, Access etc (personal)				
Internet (for work)				
Internet (personal)				
Email (for work)				
Email (personal)				

10. Please add any suggestions for the improvement of the Patterns of Eating and Activity Study (PEAS) III

Internet 100%

Appendix JJ Draft paper on the community strand of the Get a Better Life campaign

The impact of a community-based health promotion intervention using brief negotiation techniques and a pledge, on dietary intake, physical activity levels and weight outcomes: lessons learnt from an exploratory trial

Short title: Community-based health promotion intervention

Frances C Hillier[1]; Alan M Batterham[2]; Catherine A Nixon[1]; Alisha M Crayton[1]; Claire L Pedley[1]; Carolyn D Summerbell[1]

[1]Obesity Related Behaviours Research Group, School of Medicine and Health, Durham University, Stockton-on-Tees, UK
[2]Health and Social Care Institute, School of Health and Social Care, Teesside University, Middlesbrough, UK

Corresponding Author:
Frances C Hillier

Obesity Related Behaviours Research Group
School of Medicine and Health
Durham University, Queen's Campus
University Boulevard
Stockton-on-Tees
UK
TS17 6BH
Phone: +44 (0)191 3340456
Email: frances.hillier@durham.ac.uk

Abstract

Objective: To assess the effectiveness of a brief face-to-face health promotion intervention which included a ‘pledge’, using brief negotiation techniques, compared with standard advice giving techniques, delivered in a community setting.

Design: The study followed a parallel group pre-post design using randomised matched-groups. Lifestyle helpers delivered the intervention, and those working in intervention areas also received additional training in brief negotiation techniques. Diet and physical activity data were collected and anthropometric measurements taken by researchers, at baseline, six months and 12 months. Qualitative data (using lifestyle helper consultation records and a feedback questionnaire) were also collected.

Setting: Middlesbrough (UK)

Subjects: Adults living in low socioeconomic areas

Results: Recruitment and engagement of lifestyle helpers was difficult and initial expectations that local health authority staff working in the community, and community champions, would act as lifestyle helpers were not realised. As a consequence, recruitment of participants was lower than anticipated. 128 adults were recruited and retention rates were 48% at 12 months. Barriers to participation included poor health and competing commitments, although the majority of drop-outs were because of reasons unknown or being unable to contact at follow-up time points.

No significant differences in change in diet or physical activity behaviours, or BMI, between the intervention and control groups were observed. The control group had a significantly greater decrease in waist circumference at 12 months, compared with the intervention group. Lifestyle helpers reported that they needed more support than was given to them to be able to deliver the intervention satisfactorily, and would have valued ongoing support beyond the initial training session.

Conclusions: This exploratory trial provides important insights in terms of recruiting lifestyle helpers for community-based health promotion interventions, specifically i) the priorities, and limitations in terms of time, (regardless of their general enthusiasm) for staff employed by the local health authority, and ii) the willingness of potential community champions to serve their local community in areas where

community identity and 'spirit' is seen as lacking. In terms of participant recruitment to community-based health promotion interventions to achieve statistical power, we recommend using a response rate of <5% for 'hard to reach' adults, and a varied and innovative range of recruitment strategies which involve researchers attending community events in the evenings and at weekends.

Keywords: Community, intervention, diet, physical activity

Introduction

The increasing prevalence of obesity in the UK general population is a major public health concern. Most adults in the UK are already overweight but by 2050 we might expect 60% of men and 50% of women to be clinically obese, with obesity related diseases costing a predicted extra £45.5 billion per year[(1)]. Lifestyle behavioural factors play a key role in the development of obesity as well as serious health conditions such as diabetes, coronary disease and cancer. As a result, there is a growing acknowledgment that the emphasis should shift from curative approaches to preventative strategies that target lifestyle behaviours such as diet and physical activity. Communities provide key settings for obesity prevention interventions. Although some studies have shown some promising results, the evidence-base for community-based obesity prevention interventions is currently limited and inconclusive[(2-3)].

Many conventional health promotion interventions targeting poor diet and physical inactivity continue to be based upon traditional advice-giving approaches (i.e., provision of unsolicited advice and direct persuasion). This approach can be appropriate for the management of many medical conditions, but may not be effective in public health preventative programmes[(4)]. The often frustratingly small percentage of people who respond positively to advice on behaviour change, and the tendency for clinicians to label patients as 'resistant to change', can be associated with negative consequences for both parties[(5)]. Motivational interviewing and brief negotiation are "directive, client-centred counselling style[s] for eliciting behaviour change by helping clients to explore and resolve ambivalence"[(6)]. These approaches have shown encouraging results in terms of beneficial changes in physical activity (or fitness), diet behaviour and/or weight outcomes in the short-term (3-month follow-up)[7-9] and longer-term (6-month to 1-year)[7-8; 10-15].

For community-based initiatives to be effective and sustainable, involvement of community members in the delivery of interventions is recommended. ‘Shipping in’ a team of researchers to deliver interventions will only ever be a short term fix, with any benefits achieved quickly lost when the researchers withdraw at the end of the study. By training key community members, skills can be developed and passed onto the wider community for many years. More successful outcome are seen when an intervention is delivered by a member of the same community, since they are more likely to be deemed ‘trustworthy’ by other community members with whom they have shared characteristics and similar life experiences.[16-17]. Health promotion interventions delivered in community settings (compared with hospital settings) have, at least in theory, the advantage of being more accessible for socially-disadvantaged groups.

Methods

This study aimed to assess the effectiveness of a brief face-to-face health promotion intervention using brief negotiation techniques (in intervention locations), compared with standard advice giving techniques (in control locations), delivered in a community setting to promote healthy diets and levels of physical activity in adults living in low socioeconomic areas of Middlesbrough (UK). The study followed a parallel group pre-post design using randomised matched-groups. The six public health localities (PHLs) within the local health authority were assigned to intervention, control or pilot sites. Median Index of Multiple Deprivation (IMD) scores for the six PHLs were calculated using data available from the local health authority. The pair of PHLs with the most similar IMD scores was randomly assigned to either intervention or control site using a coin toss. This was performed to control for the potential confounding effect of differential levels of social deprivation between the intervention and control sites.

A key component of the health promotion intervention was a community challenge (a pledge) to improve elements of dietary intake and physical activity habits over a one year period. All participants were asked to make two specific pledges (one related to food and one related to physical activity) from three general themes; decrease dietary fat intake; increase fruit and vegetable intake; increase moderate to vigorous physical activity levels.

The literature on health promotion interventions targeted at individuals who live in low socioeconomic areas suggests relatively poor participation rates[(18)]. Specifically, this literature suggests that individuals in these areas place more value on information which is directed to the whole population, rather than just them. Consequently, an additional component was built into the design of this study; a population internet-based version of the intervention called ‘Get a Better Life’ which was targeted at all those living in Middlesbrough and surrounding areas, and was managed by the local newspaper (The Evening Gazette). This was a relatively low cost component of the study, and provided additional useful information (including data on diet and physical activity collected by a novel assessment tool) beyond acting as a lever for individuals targeted in low socioeconomic areas by the lifestyle helpers to take part in the face-to-face health promotion intervention. The findings from this internet-based intervention are reported elsewhere (Hillier *et al*., submitted).

Theoretical underpinning

This study was underpinned by two psychological models of health behaviour change: Theory of Planned Behaviour (TPB)[(19)] and Social Cognitive Theory (SCT)[(20)]. Conceptually, these theoretical models overlap considerably, as they both assume that behaviour change is ‘goal-directed’ and moderated by a person’s beliefs, perceptions and expectations about health behaviour in different social and environmental contexts. Several individual intervention strategies with evidence of effectiveness were incorporated into each brief intervention (control and intervention localities):

1) **Collaborative goal-setting (SCT)** – a plan of action to decide “what” and “extent” of change

2) **Implementation intentions (TPB)** – a strategy to help people to think in advance of how they will achieve a pledge in terms of “when and where” (e.g., in the

mornings with my cup of tea at home I will eat an apple) or strategies to resist temptations and /or overcome barriers.

3) **Eliciting social support (TPB and SCT)** – is there anyone “who” could assist you with accomplishing your pledge?

4) **Self-initiated rewards and incentives for change (SCT)** – “why” have you chosen to make this pledge?

5) **Behavioural contracting (SCT)** – a contract with oneself

The above interventions/strategies can be used to support the translation of behavioural pledges into actual behaviour. It was hypothesised that if an individual makes a pledge, they have displayed their behavioural intention to change their behaviour. According to the TPB, the only other variable that directly influences behaviour change is Perceived Behavioural Control (PBC). The intervention using brief negotiation techniques (intervention localities) incorporates strategies that aim to increase PBC by increasing the individual’s self-efficacy for making behaviour changes.

Lifestyle helpers

Lifestyle helpers were recruited to deliver the intervention. Potential lifestyle helpers employed by the local health authority were invited to participate in the study as a lifestyle helper by an invitation letter or email from their respective line managers. Also, a number of local community and voluntary organisations were contacted, and asked to invite their members, in a paid or unpaid capacity (as community champions). Individuals who were interested in becoming a lifestyle helper contacted the research team and were invited to attend one of a number a half-day training sessions (eight were run in total, over six weeks): either intervention or control sessions, depending on the location in which that individual worked. The response to invitations was lower than anticipated (the target was to train 40 lifestyle helpers), and only 15 local health authority employees, and 10 community champions (one school teacher, five community workers and four volunteers), attended the training sessions. Consequently, a third recruitment strategy was employed. Undergraduate students of Teesside University studying health related courses were invited be lifestyle helpers, and four students were trained.

The lifestyle helpers (n=29) were trained in the process of recruiting participants (consent procedure, making pledges, contract signing) with either additional training on motivational interviewing/brief negotiation techniques (intervention group), or no additional training (control group). The intervention training sessions were delivered by one member of the research team with relevant expertise who covered techniques such as reflective listening; understanding client's motivation; resisting the righting reflex; exploring readiness to behaviour change as a tool for change talk; and exploring ambivalence. The control training sessions were delivered by the other members of the research team. Of the 29 individuals trained, only four (the four students) worked as lifestyle helpers in this study.

Participants

Lifestyle helpers were asked to recruit participants in a opportunistic manner, in familiar contexts (such as health and social care initiatives targeting low-income groups [e.g., Sure Start and Health Living Centres], Local Authority community centres or participants' homes) after the primary reason for contact has been concluded. The lifestyle helper was then instructed to pass on the details of the participant to the research team so that a baseline data collection session could be arranged.

After a short time during the recruitment period, it was clear that the above strategy was not effective for the recruitment of participants. It was at this time that recruitment of lifestyle helpers was extended to include student volunteers from Teesside University who were studying on a health related course. The student volunteers were randomised into either the control or intervention group and received the appropriate lifestyle helper training. Consultations with a student lifestyle helper were arranged by the research team for individuals interested in taking part in the study.

Participants were recruited to the study during May and October 2008, via schools (parents), workplaces, community shows and events, shopping centres, community centres, shop mobility, newspaper articles and a health event held at Teesside

University. Participants were allocated to either the intervention or control group depending on the area that they lived (or worked if recruited from a workplace).

The majority of the consultations took place in the 'Life Store' (a NHS run 'drop in' centre located in Middlesbrough Town Centre that provides information on health and services with the NHS, voluntary sector and local council) but some also took place in participants' homes, at Teesside University or at local community centres/venues. The intervention was delivered by the lifestyle helper during the consultation. After the intervention had been delivered, baseline data was collected by a member of the research team. Intervention consultations took approximately 30-45 minutes to deliver and control consultations approximately 15-30 minutes.

In July 2008, as a result of low recruitment rates, the recruitment area was expanded to include the PHLs of Stockton-on-Tees and Redcar and Cleveland local health authorities. Following the same procedure as described above, two Stockton-on-Tees and two Redcar and Cleveland PHLs were assigned to the intervention and control localities.

Measures

Outcomes were measured at baseline, and at 6 months and 12 months after the consultation with a lifestyle helper. Baseline demographic data on age, gender, employment status and education were collected. A novel computer-based assessment tool (the Synchronised Nutrition and Activity Program for Adults [SNAPA™]) was used to collect data on dietary and physical activity behaviours. SNAPA™ is a computerised previous day recall program and is described in more detail, along with results of evaluation work, elsewhere (Hillier *et al.*, submitted). Participants completed SNAPA™ with the assistance of a researcher at the consultation and follow-up data collection sessions using a laptop which contained SNAPA™ on a local server. Diet and physical activity data for a second day at each time point were also collected via telephone, with a researcher inputting these data into SNAPA™. The primary outcomes were: percentage of food energy from fat; number portions of fruit and vegetables (FV); and minutes of moderate to vigorous physical activity (MVPA). Height (m), weight (kg) and waist circumference (cm) was measured by level one International Society for the Advancement of Kinanthropometry accredited researchers using appropriate guidelines[21].

The pledge data collected during the consultation provided useful information on the types of behaviours that were targeted by the participants. All participants who signed up to the campaign (including drop-outs) were sent a feedback questionnaire after the 12 month data collection was completed. Participants were also invited to take part in a semi-structured interview to explore participant's experiences. A full description of methods used and findings from the semi-structured interviews are reported separately (Nixon *et al.,* submitted).

Data analysis

Analysis was carried out using mean values of the diet and physical activity outcomes from the two days collected. A screening criterion was applied to the physical activity data to remove unfeasible data before analysis to indentify any changes between baseline and follow-up levels was performed. Over-reporters were defined as MVPA>480 minutes per day (the approximate time, at the minimum threshold for MVPA of three metabolic equivalents [METs], to achieve a maximum sustainable PAL of 2.5[22]).

Data were analysed using an analysis of covariance (ANCOVA) model, with the baseline scores as covariate to control for potential imbalances between groups at baseline. This model is generally more efficient than analysis of post scores only (ignoring baseline) or analysis of change scores (post minus pre). The primary comparison is the difference in the change in portions of fruit and vegetable consumption (F&V) between the intervention and control at 12 months (given by the coefficient b, below), though the sixmonth outcomes were also explored:

$$\text{F\&V (12 months)} = a + b \cdot \text{group (intervention, control)} + c \cdot \text{baseline F\&V}.$$

Number of portions of F&V is treated as a continuous variable rather than a count, as it is based on multiples of portion size and may be fractional. This model adjusts for baseline imbalance and provides the between-group difference in the change in F&V

from baseline to follow-up. The same model was applied to the dietary fat and physical activity outcomes. Given the substantial proportion of zero values and oddly-shaped distributions, confidence intervals were constructed via a criterion nonparametric bootstrapping method[(23)]. On each of 10000 resampling runs, n cases (given by the sample size) were randomly selected with replacement from within the original data (maintaining case correspondence). Each time, the mean difference (adjusted for baseline) between baseline and 6 months (or baseline and 12 months) was calculated and stored. The 90% confidence interval for the population mean difference was then derived by taking the 5th and 95th percentile of the 10000 stored differences (Resampling Stats v.4.0.7, Resampling Stats Inc., Arlington, Virginia). The ANCOVA method described above was applied to the BMI and weight outcomes, but with confidence intervals constructed via standard parametric analytic formulae.

Power calculation

The sample size estimation was matched explicitly to the intended analysis. To provide a more robust estimate of habitual behaviours and reduce noise in the measurement, participants were asked to complete two baseline and two post-intervention assessments. A correlation between baseline measures of 0.7, between follow-up measures of 0.7, and between baseline and follow-up of 0.5 was assumed (realistic, conservative estimates for self-report tools based on unpublished observations). For 90% power to detect the intervention effect of half a portion (2P = 0.05) the Stata® 'method ANCOVA' produced a required sample size of 189 participants in each group (based on a estimated population standard deviation of 2.01 portions taken from the National Diet and Nutrition Survey[(24)]). An allowance for attrition of 30% inflates the target N to 270 participants in each arm.

It was recognised that in this community study individuals are not the unit of randomisation. Rather, two public health locality team areas are randomly allocated to each arm. Hence, theoretically there is some element of clustering. This could not be accounted for post-study by multilevel modelling/SAS Proc Mixed type procedures as there were insufficient number of clusters in each arm to estimate the variances. Data were therefore analysed at the individual level. A negligible intraclass correlation for this pragmatic community trial was assumed and hence no allowance was made for any design effect of clustering.

Results

Recruitment of participants

A total of 128 people (69 intervention, 59 control) were recruited to the health promotion intervention, falling well short of the anticipated number required to achieve power. Retention rates were similar in both groups, and at each follow-up data collection time point (between 47% and 49%). All participants who had been unable to attend a six month data collection session for whatever reason (e.g. illness, lack of time, competing commitments) were still invited to attend a 12 month data collection session, unless they had informed the research team they no longer wished to take part in the study. Reasons for dropping out of the study included illness of participant or a family member (n=11), too busy with other commitments (n=6) and moving away from the area (n=2). The remaining dropouts were for reasons unknown (n=24) or being unable to contact at follow-up time points (n=22).

The mean age of participants in each group ranged from 41.6 to 49.1 years of age, throughout the data collection periods. The control group contained a greater proportion of men than the intervention, consistently over the year. This was probably as a result of a number of male participants (n=9) who were recruited through the workplace Corus Steel, located in one of the control areas.

Pledges and reason for taking part

Table 1 displays a breakdown of the behaviours that the participant's pledges targeted. Although encouraged to pledge against either fat intake or fruit and vegetable intake, some participants, as an addition, included other behaviours (for example, alcohol, salt or sugar intake, and smaller portion sizes) in their diet pledge.

The main goal of taking part in the health promotion intervention, identified in the feedback questionnaires, was to lose weight. Other goals indentified were improving fitness, achieving a healthier lifestyle, and achieving a healthier diet.

Diet, physical activity and anthropometric outcomes

Tables 2 and 3 show the diet and physical activity behaviour outcomes at each data collection time point. Mean and median values are reported for participants providing data at both time points (baseline vs. 6 months; baseline vs. 12 months). Daily percentage of food energy from fat ranged between mean values of 32.1% and 35.0% in the control group, and between 29.7% and 32.7% in the intervention group, over the period of the study. Fruit and vegetable intake ranged between means of 3.2 and 3.9 portions per day in the control group, and between 3.0 and 4.0 portions per day in the intervention group. For minutes of moderate to vigorous activity per day, data were skewed towards zero; therefore, it may be more appropriate to consider the median value when interpreting these data. Median values between zero and 30 minutes of MVPA per day were observed in the control group over the duration of the study, and between zero and 21 minutes was observed in the control group. ANCOVA analysis revealed no significant intervention effect on any of the diet and physical activity behaviour outcomes (Table 4).

Tables 5 and 6 show the anthropometric outcomes at each data collection time point. Weight and BMI remained fairly consistent with baseline at six months, with slight decreases in weight and BMI at 12 months in both groups. There were no significant differences in the change in weight or BMI between both groups at either time point (Table 7). An increase in waist circumference was observed in the intervention group at 12 months, where as small decreases were observed in the control group at both six and 12 months. This resulted in an overall significant increase in waist circumference as a result of the intervention, controlling for changes in the control group (Table 7).

Experience of taking part

Thirty-one participants completed the feedback questionnaire. Responses to the feedback questionnaire were anonymous; therefore, we are unable to identify the demographic characteristics or which group the participants were assigned to. The majority of responders (96.8%) gave high rating scores for the consultation session with the lifestyle helper. A number of respondents rated family, friends and/or colleagues as being of particular help in working towards their pledges (48.1%). The most common barriers to making healthful changes and working towards pledges identified in the feedback questionnaire responses were: physical barriers, e.g. health problems (31%); psychological barriers, e.g. lack of motivation (27.6%); and lack of support (20.7%). Data from the semi-structured interviews supported findings from the feedback question, and allowed the identification and exploration of a number of themes (Nixon *et al.,* submitted).

Discussion

The original plan was to recruit participants through the trained lifestyle helpers who had existing roles in the community. However, despite feedback from those who were trained as Lifestyle healpers of their enthusiasm and confidence to deliver the intervention, 26 out of the 30 individuals trained did not fulfil their role as a lifestyle helper. Only the four student volunteers delivered consultations, at appointments pre-arranged by the research team. Findings reported elsewhere (Nixon *et al.,* submitted) and anecdotal evidence collected through field notes, suggest that those trained as lifestyle helpers found putting what was learnt into practice more difficult than anticipated. Local health authority employees who were trained as lifestyle helpers reported that they were hampered by a lack of time to deliver the intervention. Even those employees who were very motivated to deliver the intervention were unable to do so, as they felt there was insufficient time during a typical visit with their clients, especially as the primary reason for the visit was related to their every-day roles and duties, and not the intervention. Although essential, procedures to ensure informed consent are also time consuming and can seem complex, and may have proved a step too far for an opportunistic intervention. Time constraints and difficulty with consent procedures have been previously identified as barriers for participation in research by health professionals[(25)]. The organisational structure of the public health workforce in England continues to change, and employees reported that meeting the needs of these changes was challenging, and their priority, and as such the delivery of the intervention was sidelined. There was significant organisational change in the local health authority of Middlesbrough at the time of the study, and the resulting anxiety and time pressures experienced by some employees was deemed to be an additional barrier to delivering consultations.

A number of local health authority employees contacted through this study, who could not commit to a lifestyle helper role, were enthusiastic about the study and extremely helpful in signposting the research team to other individuals and groups in the community. Local health authority employees working in the community will have a wealth of knowledge, acquired over time, that a researcher could never achieve, and involving these staff as a gateway into communities may be a more successful approach. On reflection, too much reliance was placed on local health authority employees to act as lifestyle helpers in this study. The strategy for recruiting community champions was through contacts with existing community networks and organisations; however, different strategies may have been more effective. Examples from other studies where community members have been recruited to deliver interventions include direct advertising in local media(26) and employing workers on a part-time basis(12). The original aim of this study was to use known community members as community champions, as this is considered a more effective approach to community-based health promotion(16-17). The student volunteers who delivered the intervention were not previously known by the participants, which may have affected the recruitment and retention rates experienced in this study.

The low recruitment rate of lifestyle helpers led to difficulties recruiting the required number of participants. An estimate of recruitment rate was taken using researcher field notes during the active canvassing sessions at shopping centres, community events and a health event held at Teesside University. Approximately 1 in 20 of those who were approached during these sessions were recruited to the study and completed a consultation with a lifestyle helper.

A relatively effective way of recruiting participants was through community groups; schools and workplaces. The project team not only actively contacted a number of these organisations, but were also contacted spontaneously by some groups. A main contact was identified within the group or organisation who took on a ‘peer leader’ role, where they would spread the word of the campaign to other group members and assist in the arrangement of group consultation sessions.

The lack of effect of a brief intervention on diet and physical activity behaviours may be the result of the intervention being insufficiently strong enough to promote a change in behaviour. In the majority of previous studies using motivational interviewing techniques, more than one session was delivered[(27)], whereas only one session was used in this study However, in one childhood obesity prevention study where sessions were delivered to parents, decreases in BMI were observed in both the group receiving a minimal intervention (one motivational interviewing session) and the group receiving an intensive intervention (two motivational interviewing sessions), with no significant differences between the groups[(28)]; the intervention lifestyle helpers were given the Behaviour Change Counselling Index (BECCI) and were encouraged to use this to self-monitor their performance when delivering the consultations. However, since no formal fidelity measures were taken with the children, treatment integrity of the intervention consultations over the course of this study is unknown.

The effect of the intervention on waist circumference in this study is unexpected (decreased in the control group compared with the intervention group). This finding is unlikely to be a result of measurement error; all researchers were II ISAK accredited level one anthropometrics trained in waist circumference measurement.

A lack of intervention effect on diet and physical activity behaviour may also be a result of limitations in the data collection method used. SNAPA™ showed reasonable correlations with standard methods of dietary and physical activity assessment (Hillier *et al.*, submitted); however, we recognise the limitations of self-report methods in the assessment of diet and physical activity, mainly due to the increased error (imprecision) of self report methods. The original sample size estimation took into account this inflated measurement error and was calculated using the standard deviations from results from the SNAPA™ evaluation work (unpublished results). This would have ensured that, despite the error associated with the tool, there would be sufficient power to detect differences between the control and intervention groups in changes to the main outcome variables from baseline to 12 months if the estimated numbers had been recruited and retained.

Another limitation of SNAPA™ is the unknown ability of it to detect changes in behaviour over time. Therefore, it is unclear if the observed lack of intervention effect is real or if the assessment method was unable to detect any changes which did occur. This is a common problem in intervention research and, despite the importance of using a tool which can assess change, the ability of assessment tools used in intervention studies to detect change is rarely reported in the literature[(29-39)].

The results of the current study suggest that SNAPA™ may be more robust in terms of dietary compared with physical activity assessment. Self-reported methods for the assessment of diet and physical activity have many errors associated with them, however it may be the case that food items and meals are easier to define than time spent doing activity at a certain intensity and hence result in more accurate recall of dietary information. In future studies of this type, the addition of an objective measure such as accelerometry would be recommended (at least on a sub-sample of the population) to provide more stable physical activity data, along with the contextual data provided by SNAPA™. Accelerometry is now a widely used method for the measurement of physical activity, and has been used in national surveys in the England and the US[(40-41)].

Conclusion

This exploratory study provides valuable information on the processes involved in implementing a community-based health promotion intervention. In terms of recruiting Lifestyle helpers for community-based health promotion interventions it is important to consider the priorities, and limitations in terms of time, (regardless of their general enthusiasm) for staff employed by the local health authority. It is also important not to overestimate the willingness of potential community champions to serve their local community in areas where community identity and ‘spirit’ is seen as lacking.

In terms of recruiting participants to community-based health promotion interventions, we suggest that a varied and innovative range of recruitment strategies are employed which involve researchers attending community events in the evenings and at weekends. The lessons learnt from this study may be useful for the development and implementation of future community-based obesity prevention interventions.

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Tables

Table 1 Categories of pledges made by participants, n=128

Pledge	***n***	**%**
Diet pledges		
Increase fruit & vegetable intake	55	43.0
Reduce fat	23	18.0
Reduce unhealthy snacks	34	26.6
Reduce salt	2	1.6
Reduce sugar	2	1.6
Eat healthy snacks	2	1.6
Reduce take-away/processed foods	9	7.0
Reduce alcohol	2	1.6
Change cooking method (e.g. grill instead of fry)	5	3.9
Eat healthy/balanced meals	15	11.7
Eat smaller portions	5	3.9
Replace high fat/sugary foods with healthier alternatives	12	9.4
Physical activity pledges		
Exercise once/week	4	3.1
Exercise twice/week	3	2.3
Exercise three or more times/week	11	8.6
Walking	56	43.8
Cycling/use exercise bike	5	3.9
Gym/keep fit class	25	19.5
Jogging/running	6	4.7
Swimming/aqua aerobics	10	7.8
Wii Fit/other training equipment	14	10.9
Maintain current physical activity levels	20	15.6

Note: Total frequencies for each type of pledges exceeds 128, as some participants targeted more than one behaviour within one/each pledge

Table 2 Diet and physical activity outcomes at baseline and 6 months

	Control (n=28)				Intervention (n=33)			
	Baseline		6 months		Baseline		6 months	
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)
% Food energy from fat	34.4 (8.9)	34.2 (17.8-52.7)	35.0 (8.1)	35.4 (18.8-54.4)	32.7 (7.9)	34.9 (17.7-51.7)	32.2 (8.3)	32.6 (8.6-46.2)
Fruit and vegetable portions	3.9 (3.4)	3.1 (0.0-12.0)	3.2 (2.3)	3.0 (0.0-9.6)	3.0 (2.1)	3.0 (0.0-7.0)	3.3 (2.6)	2.8 (0.0-9.0)
Minutes MVPA	35.9 (38.6)	30.0 (0.0-135.0)	36.3 (69.6)	0.0 (0.0-232.5)	47.3 (74.6)	17.5 (0.0-330.0)	31.1 (61.7)	0.0 (0.0-240.0)

SD – standard deviation; MVPA – moderate to vigorous physical activity

Table 3 Diet and physical activity outcomes at baseline and 12 months

	Control (n=29)				Intervention (n=34)			
	Baseline		12 months		Baseline		12 months	
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)
% Food energy from fat	34.3 (7.7)	34.9 (18.2-48.8)	32.1 (7.9)	32.7 (9.4-46.8)	32.1 (8.9)	34.7 (7.7-49.4)	29.7 (9.8)	28.5 (7.9-12.0)
Fruit and vegetable portions	3.7 (3.3)	2.5 (0.0-12.0)	3.6 (2.8)	2.6 (0.6-13.0)	3.2 (2.6)	3.0 (0.0-12.0)	4.0 (2.8)	3.6 (0.0-13.0)
Minutes MVPA	23.5 (36.4)	0.0 (0.0-135.0)	49.8 (105.7)	0.0 (0.0-420)	46.8 (71.3)	21.3 (0.0-330)	37.5 (62.3)	15.0 (0.0-300)

SD – standard deviation; MVPA – moderate to vigorous physical activity

Table 4 Mean effect of the intervention (intervention minus control) for diet and physical activity outcomes at 6 months and 12 months (adjusted for baseline in an ANCOVA model; baseline vs. 6months, control n=28, intervention n=33; baseline vs. 12 months, control n=29, intervention n=34)

	Mean change (bootstrapped 90% CI) 6 months	Mean change (bootstrapped 90% CI) 12 months
% Food energy from fat	-2.6 (-6.2 to 1.0)	-1.6 (-5.1 to 1.7)
Fruit and vegetable portions	0.5 (-0.5 to 1.3)	0.6 (-0.4 to 1.5)
Minutes MVPA	-4 (-37 to 25)	-12 (-50 to 23)

CI – confidence interval; MVPA – moderate to vigorous physical activity

Table 5 Weight, body mass index (BMI) and waist circumference at baseline and 6 months, Mean (SD)

	Control (n=26)		Intervention (n=30)	
	Baseline	6 months	Baseline	6 months
Weight (kg)	80.0 (18.1)	80.0 (18.4)	80.2 (15.7)	79.5 (16.4)
BMI (kg/m^2)	27.9 (5.3)	27.9 (5.4)	29.9 (4.8)	29.6 (4.9)
Waist circumference (cm)	94.7 (13.8)	93.8 (14.9)	96.1 (12.0)	98.2 (12.5)

SD – standard deviation

Table 6 Weight, body mass index (BMI) and waist circumference at baseline and 12 months, Mean (SD)

	Control (n=24)		Intervention (n=31)	
	Baseline	12 months	Baseline	12 months
Weight (kg)	76.2 (16.4)	75.3 (16.1)	79.4 (16.3)	75.5 (21.1)
BMI (kg/m^2)	27.7 (4.8)	27.4 (4.8)	29.9 (5.8)	28.5 (7.8)
Waist circumference (cm)	93.2 (12.4)	92.5 (13.0)	95.3 (12.1)	95.0 (22.0)

SD – standard deviation

Table 7 Mean effect of the intervention (intervention minus control) for weight, body mass index (BMI) and waist circumference at 6 months and 12 months (adjusted for baseline in an ANCOVA model; baseline vs. 6 months, control n=26, intervention n=30; baseline vs. 12 months, control n=29, intervention n=34)

	Mean change (90% CI) 6 months	Mean change (90% CI) 12 months
Weight (kg)	-0.70 (-1.97 to 0.56)	0.15 (-1.54 to 1.84)
BMI (kg/m^2)	-0.29 (-0.76 to 0.18)	0.05 (-0.55 to 0.65)
Waist circumference (cm)	3.1 (1.2 to 5.0)	3.6 (0.8 to 6.3)

CI – confidence interval

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Appendix KK Draft paper on the internet strand of the Get a Better Life campaign

An internet-based, health promotion media campaign (Get a Better Life) aimed at improving diet and physical activity: recruitment, retention and feasibility

Short title: An internet-based, health promotion campaign

Frances C Hillier[1]; Alan M Batterham[2]; Catherine A Nixon[1]; Alisha M Crayton[1]; Claire L Pedley[1]; Carolyn D Summerbell[1]

[1]Obesity Related Behaviours Research Group, School of Medicine and Health, Durham University, Stockton-on-Tees, UK
[2]Health and Social Care Institute, School of Health and Social Care, Teesside University, Middlesbrough, UK

Corresponding Author:
Frances C Hillier

Obesity Related Behaviours Research Group
School of Medicine and Health
Durham University, Queen's Campus
University Boulevard
Stockton-on-Tees
UK
TS17 6BH
Phone: +44 (0)191 3340456
Email: frances.hillier@durham.ac.uk

Abstract

Objective: To evaluate an internet-based health promotion media campaign called 'Get a Better Life' (GABL) which was aimed at encouraging adults to make healthy changes to their diet and physical activity behaviours.
Design: In a controlled before-after study participants were invited to make two pledges: one against improving diet (either decreasing fat intake or increasing fruit and vegetable intake) and one against increasing physical activity levels. Participants worked towards their pledges for one year, using support from the campaign website. Diet and physical activity behaviours were assessed at baseline, six months and 12 months.
Setting: Teesside (UK)
Subjects: 1073 adults
Results: Retention to the campaign was low with only 57 (6.0%) and 84 (8.8%) providing data at six month and 12 month follow-up, respectively. There were no significant changes in diet or physical activity outcomes between baseline and follow-up, however these results need to be interpreted with caution due to the high attrition rates. No major usability problems in using the website were identified. More IT support than originally anticipated was required for the maintenance of the website and the assessment tool.
Conclusions: Despite the lack of evidence of effectiveness of GABL, important lessons were learnt with regard to recruitment, retention and feasibility. Internet based health promotion interventions may be particularly useful in reaching those who prefer a non-directive and remote approach, and are eminently feasible when conducted in partnership with a local media group. This type of approach is also relatively inexpensive compared with traditional methods of health promotion.

Keywords

Obesity prevention, physical activity, diet, internet, media campaign, health promotion

Introduction

The increasing prevalence of obesity in the UK population is a major public health concern. Finding effective ways of promoting healthy lifestyles, in particular encouraging healthy eating habits and increasing physical activity, in the general population is a priority for those working in the public health field. The continued rise of popularity and use of the internet makes it a medium of considerable interest and potential for public health interventions. In the UK in 2009, 18.3 million (70%) households had Internet access compared with 14.3 million (57%) in 2006[1]. The number of people using the internet for searching for health related information has also increased over recent years[1-2].

Using the internet to promote healthy eating and physical activity has become increasingly popular over recent years. A small number of short-term workplace web-based interventions have shown promising results in terms of weight loss[3-5], and favourable changes in eating behaviour[6-7], with relatively low attrition rates of approximately 20% (with the exception of the study by Block *et al.* that had a 44% attrition rate[6]). However, effectiveness in terms of changing physical activity behaviour is less clear and a clinical behavioural weight loss program delivered online, with a longer follow-up period, was less effective than in-person support at facilitating long-term weight loss[8]. Using internet approaches in clinical and public health interventions also appears to be less successful in terms of retention[9-10], a major concern in the field of internet-based health promotion[11].

The use of large scale media campaigns is a traditional approach for health promotion, compared with internet-based strategies which have been used (in particular) for targeting physical activity behaviours. Although a number of these media campaigns and internet-based strategies have been effective in promoting awareness and increasing interest in physical activity, this has not translated into actual improved behaviour in some studies[12]. A more recent community-based multi-strategy approach (including a local media campaign) carried out in the town of Ghent in Belgium, however, not only increased awareness of the "10,000 steps a day message", but also increased pedometer-determined activity when compared with a comparison community[13].

The aim of this study was to evaluate the internet-based health promotion media campaign called 'Get a Better Life' (GABL), which was aimed at encouraging adults living in the Teesside (North East of England) to make healthy changes to their diet and physical activity behaviours. A community-based face-to-face version of the intervention was delivered in parallel with GABL, the findings of which are reported elsewhere (Hillier *et al.*, submitted).

Methods

Recruitment of participants

GABL was delivered via a dedicated website between January 2008 and May 2009. The campaign was promoted through advertisements and features published in the local newspaper (The Evening Gazette), and its website (www.gazettelive.co.uk). People interested in taking part were instructed to visit the campaign website (www.getabetterlifecampaign.co.uk) which contained more information about the campaign and a link to the registration process.

During the registration process participants were asked to make two pledges: one against improving diet (either decreasing fat intake or increasing fruit and vegetable intake) and one against increasing physical activity levels. Participants could select a pledge from three examples given, or they could enter their own pledge(s). Pledges that targeted everyday behaviours and that could be realistically achieved were encouraged. Participants were instructed to work towards their pledges over the next 12 months and access the campaign website for information and support.

The 'Get a Better Life' campaign

Only participants who had completed the registration process had full access to the GABL website. The website contained healthy eating and physical activity information to help participants achieve their pledges, along with recipes, news of local events, news stories relating to GABL and links to relevant nutrition, physical activity and other useful sites.

During the intervention period, regular stories were published about the campaign, in the 'Evening Gazette', and it's website, to promote public awareness of and engagement with the campaign. Between January 2008 and June 2009, the 'Get a Better Life' campaign had over 150 mentions in the Evening Gazette, including a front page launch and supplements, regular news, features and family life stories.

Theoretical underpinning

The GABL campaign was underpinned by two psychological models of health behaviour change: (1) Theory of Planned Behaviour (TBP)(14) and Social Cognitive Theory (SCT)(15). Conceptually, these theoretical models overlap considerably, as they both assume that behaviour change is 'goal-directed' and moderated by a person's beliefs, perceptions and expectations about health behaviour in different social and environmental contexts. Several individual intervention strategies were incorporated into the GABL campaign:

1) Collaborative goal-setting (SCT) – a plan of action to decide "what" and "extent" of change
2) Implementation intentions (TPB) – a strategy to help people to think in advance of how they will achieve a pledge in terms of "when and where" (e.g., in the mornings with my cup of tea at home I will eat an apple) or strategies to resist temptations and /or overcome barriers.
3) Eliciting social support (TPB and SCT) – is there anyone "who" could assist you with accomplishing your pledge?
4) Self-initiated rewards and incentives for change (SCT) – "why" have you chosen to make this pledge?
5) Behavioural contracting (SCT) – a contract with oneself

Measures

The number of visits to the GABL website per month was monitored using a data collection facility (Webalizer Version 2.01) which was provided as part of the website hosting package (lunarpages®: Add2Net, Inc, Anaheim, CA). A novel web-based assessment tool (the Synchronised Nutrition and Activity Program for Adults [SNAPA™]) was used to collect data on dietary and physical activity behaviours for all participants. SNAPA™ is a computerised previous day recall program and is described in more detail, along with results of evaluation work, elsewhere (Hillier *et al.*, submitted). The primary outcomes for this study were: Percentage of food energy from fat; number portions of fruit and vegetables (FV); and minutes of moderate to vigorous physical activity (MVPA).

Participants completed SNAPA™ once at baseline (during registration), 6 months and 12 months (prompted by reminder emails and news stories in the Gazette). This was done wherever the participant had internet access (for example, home, work or library). The majority of participants completed SNAPA™ remotely (without the assistance of a researcher). Initially, support sessions were arranged in community venues with internet access where researchers were available to help people register and complete SNAPA™, however these were poorly attended and were not repeated at the follow-up data collection time points.

Demographic data on age, gender, employment status, education level and postcode were collected during the registration process. Participants reported their height at baseline and their weight at baseline, 6 months and 12 months.

Pledge data and data on reasons for taking part in the campaign collected during the registration process also provided useful information on the behaviours targeted and initial motivations for taking part in the campaign. At the end of the campaign, all participants who originally signed up to the campaign where sent a link to an internet-based feedback questionnaire. Participants were also invited to take part in a semi-structured interview to explore participant's experiences. A full description of methods used and findings from the semi-structured interviews are reported separately (Nixon *et al.,* submitted).

Data analysis

Diet and physical activity outcomes

Basic descriptive statistics were carried out on the diet and physical activity outcomes of the sample of participants who provided data at baseline and six months, baseline and 12 month. However, data for the participants who reported that the day on which they recalled was an ‘abnormal day’ was removed from the analysis as an attempt to screen for any unrepresentative data. For the physical activity data analysis, over-reporters were defined as MVPA >480 minutes (the approximate time, at the minimum threshold for MVPA of three metabolic equivalents [METs], to achieve a maximum sustainable PAL of 2.5[16]) and these over-reporters were removed from the secondary analysis.

Given the substantial proportion of zero values and oddly-shaped distributions comparisons between baseline and six month, and baseline and 12-month diet and physical activity data were conducted using a criterion nonparametric bootstrapping method[17] based simply on the change from baseline to follow-up (equivalent to a paired t-analysis but more appropriate for badly behaved residuals). On each of 10000 resampling runs, n cases (given by the sample size) were randomly selected with replacement from within the original data (maintaining case correspondence). Each time, the mean difference (adjusted for baseline) between baseline and six months (or baseline and 12 months) was calculated and stored. The 90% confidence interval for the population mean difference was then derived by taking the 5th and 95th percentile of the 10000 stored differences (Resampling Stats v.4.0.7, Resampling Stats Inc., Arlington, Virginia). Differences between weight and BMI at baseline and six months, and baseline and 12 months, were analysed using paired t-test statistical analysis.

Results

Recruitment and retention

A total of 1073 people registered to GABL via the campaign website, however when follow-up contact was made 117 emails proved to be invalid leaving 956 participants remaining. Of those 956 participants, only 57 (6.0%) and 84 (8.8%) completed SNAPA™ at six month and 12 month follow-up respectively. Only eight participants actively dropped-out of the study (by asking to be removed from the email mailing list). The remaining participants were classified as non-responders.

Demographics

The sample characteristics of the GABL participants are displayed in Table 1. The mean of age the participants remained in the early forties throughout the campaign period, and the proportion of women participants remained fairly consistent at approximate 2/3 of the sample. The proportion of participants with a University or postgraduate degree increased from 25% at baseline to 46% at both 6 and 12 month follow-up, whereas the proportion of participants whose highest education was at secondary school or GCSE level, decreased from 43% at baseline to 19% and 21% at 6 and 12 months follow-up, respectively. There were no other large variations in any of the other demographic characteristics from baseline to follow-up.

Pledges – behaviours targeted

Details of the pledges made by the participants are reported in Table 2. In terms of the diet pledge, where participants had a choice to target either fat or fruit and vegetable intake, a slightly higher number of participants pledged against decreasing fat intake.

The majority of participants chose one of the three pledges per behaviour that were suggested as examples during the registration process, although there were slightly more participants who chose their own physical activity pledge compared with those who chose their own diet pledge The example pledges were compiled using data from pilot research (for this project) on diet and physical activity habits of local adults (unpublished results). .

Reasons for taking part

During the registration process, participants were asked to record the reasons why they were taking part in the campaign (or reasons for their pledges). Table 3 shows the themes of the reasons given. The most common reasons for taking part were related to ‘health and fitness’ (72.2%), with reasons associated with ‘weight’ (reducing and/or managing) the second most common (44.6%).

Website usage

The number of visits to the GABL website for each month that the campaign was 'live' is shown in Figure 1. As expected, there were a relatively high number of visits during the first month when the campaign was 'launched' with a high amount of media coverage in the local newspaper. However, the highest number of visits occurred in April 2009, which was the beginning of the 12 month data collection period. During this time, a number of emails were sent to participants, reminding them to complete the 12 month data collection process, along with a number of articles in the local newspaper. However, the rise in the number of visits to the website, was not reflected in the numbers completing the final data collection

Dietary and physical activity outcomes

The targeted diet and physical activity behaviour outcomes are displayed in Tables 4 to 7. There were no significant changes in any of the outcome behaviours between baseline and six months, or baseline and 12 months (Table 8). However, in terms of fat intake, the mean change appears to be approaching significance in the direction of decreasing fat intake at both six and 12 months.

Anthropometric data

Self-reported BMI and weight outcomes for the participants are displayed in Tables 9 and 10. There were no significant changes in either weight or BMI from baseline to six months, or baseline to 12 months.

Experience of taking part

Fifty eight participants completed the online feedback form. As responses to the feedback questionnaire were completely anonymous, we are unable to report the demographic characteristics of this sample. No major usability issues when using the website and SNAPA™ were identified from the comments, however some respondents stated that the process was somewhat 'tedious', 'time-consuming' and/or 'fiddly'. Despite this, respondents were very pleased with the online feedback they had received during the campaign, and had used this information to evaluate their progress and make necessary changes. Many respondents suggested that more regular feedback would be useful.

Discussion

Recruitment and retention

The retention rates in this study were disappointingly low. However, sustaining engagement in web-based interventions over long periods of time is a challenge that has been identified by others[9-11; 18], and an issue which this project attempted to explore Even in the short-term, dropping out of a web-based study is very easy. As Birnbaum[19] describes, "Web participants are free of…social pressure or embarrassment. They simply click a button to quit…and do something else". In a study by O'Neil and Penrod, drop-out rates were monitored over the study registration process which included four web-pages (page 1: introduction and general instructions; page 2: consent form with some additional questions; page 3: research materials and questions relating to these; and page 4: demographic questions)[20]. Of 791 participants who accessed the first page, 409 reached the second page, 282 the third page and 193 (22.4% of the beginning sample) completed the study[20].

Some workplace internet-based interventions have shown some promising results, with relatively low drop-out rates[3-5; 7]. These interventions were carried out over shorter time periods (two programs were 12 weeks and two six months) and in relatively controlled conditions where internet access was readily available. These programs were also reasonably structured with regular contact via email (and in some cases in addition to face-to-face and telephone contact) and monitoring of behaviours. GABL was a fairly 'light touch' intervention in comparison, with a small amount of email contact (no more than once a month) and monitoring at just the three data collection time-points (baseline, six months and 12 months). Participants were free to use the website as often or as little as desired. A more structured, directive intervention may have improved engagement for those who felt isolated. However, some participants reported that the freedom of the non-directive approach used was the aspect of the project which they found most appealing (Nixon *et al.*, submitted). Tailored approaches to internet-based interventions may offer a solution for meeting the different, complex needs of individual participants[21].

Despite the initial interest and recruitment to GABL, it is clear that maintaining engagement in this type of intervention is difficult over longer time periods of six months and a year. It may be possible that participants were still working towards their pledges and continuing to take part in the campaign but, for whatever reason, did not complete SNAPA™ at the follow-up time points. This may be explained by the continued usage of the website but lack of follow-up data, however we have no evidence to support this.

Data collection methods

From the results of this pilot study, SNAPA™ appears to be more robust in terms of dietary compared with physical activity assessment. There was a wide variation in the physical activity data reported, often highly skewed to 0 minutes of MVPA, but with what appears to be significantly over-reported values. The limitations of self-reported data for both dietary and physical activity assessment are well known, however recall of distinct food items and meals may be easier than periods of physical activity which can be difficult to define in terms of duration and intensity.

No major problems relating to the completion of SNAPA™ were reported in the feedback received or during the evaluation work carried out with the program (Hillier *et al.*, submitted; unpublished results). However, when SNAPA™ was used in the 'real world' for this study, there were some participants who found the program difficult to complete. A small number of participants contacted the enquiries email address or hotline, where a member of the team could talk them through the problem. Support sessions were arranged during the baseline data collection period at local libraries/public internet access venues where members of the research team were available to assist with any usability issues; however these were very poorly attended and not repeated at follow-up data collection periods.

One limitation of the data collected in this study was that only one day of data was collected for each participant at each time point. In the choice of dietary and physical activity methods of assessment there is a difficult balance between accuracy and feasibility. For the assessment of habitual behaviour, it is well established that the accuracy increases as the number of days of data collected increase. However, in turn, the burden on the participant also increases. If data is collected from a sufficient number of individuals who are representative of the population of interest, single 24 hour recalls or one day diet records can be used to describe average intakes of the group robustly as this is not affected by within person variation[(22-23)]. For this study (taking into account our learning from the pilot study), we chose to only ask for one day of data to minimise participant burden and believed this would be sufficient for analysis at a group level.

Another limitation is the unknown ability of SNAPA™ to detect changes in behaviour over time, in response to an intervention. Therefore, the observed lack of intervention effect may be real or simply that the assessment method was unable to capture any changes that did occur. Unfortunately, the ability of assessment tools used in intervention studies to detect change is rarely reported in the literature, and studies that have been published are mainly food frequency questionnaire evaluations[(24-25)].

It is clear that further development and a more rigorous evaluation of SNAPA™ are required. Future work planned by Durham University will determine the accuracy and feasibility of SNAPA™ for use in a range of settings (in particular remote settings), and the ability of the program to assess change over time.

To add strength to future studies of this type, the additional use of an objective measure of physical activity is recommended (at least on a sub-sample of the population); alongside the contextual data provided by a self-reported method such as SNAPA™. Accelerometry is now a widely used method for the measurement of physical activity, due to the ease of use in free-living populations and relatively low cost, and is now part of national surveys in England and the US[(26-27)].

Feasibility

The maintenance of the website was relatively inexpensive at approximately £50 per year when a hosting package for a number of years was purchased. The website was initially set up with the assistance of a computer programmer, and the day-to-day running of the site was performed by a member of the research team who received some basic training. However, more IT support than was originally anticipated was required for the more complex maintenance of the website and, in particular, SNAPA™.

The partnership between the research team and the local media group was perceived by both partners to be invaluable in the successful recruitment of participants to GABL. Over half of participants who signed up did so within the first week of the media campaign launch, during which a dedicated launch supplement and daily articles were published in the Evening Gazette.

Conclusion

The effectiveness of this internet-based health promotion intervention (the Get a Better Life media campaign) could not be assessed due to the low retention rates in this study. However, important lessons were learned from this study in terms of recruitment and retention, and feasibility, which could be useful to consider when developing similar interventions. The results of this study showed that Internet based health promotion interventions may be particularly useful in reaching those who prefer a non-directive and remote approach, and are eminently feasible when conducted in partnership with a local media group. This type of approach also has the advantage (over traditional methods of health promotion) of being relatively inexpensive. Low levels of retention commonly seen in internet-based health promotion interventions may be reduced by providing regular personalised feedback.

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Tables

Table 1: Sample characteristics of the 'Get a Better Life' participants at baseline and follow-up.

	Baseline (n=1073)	6 months (n=57)	12 months (n=84)
Age (years)	40.2 (16-91)	43.5 (18-73)	43.0 (17-73)
Gender			
Male	315 (29.4)	19 (33.3)	25 (29.8)
Female	753 (70.2)	37 (64.9)	58 (69.0)
Not reported	5 (0.5)	1 (1.8)	1 (1.2)
Employment			
Employed Full-Time	515 (48.0)	33 (57.9)	48 (57.1)
Employed Part-Time	153 (14.3)	7 (12.3)	13 (15.5)
Self-Employed	43 (4.0)	2 (3.5)	1 (1.2)
Unemployed	179 (16.7)	5 (8.8)	9 (10.7)
Homemaker	120 (11.2)	8 (14.0)	10 (11.9)
Full-Time Education	47 (4.4)	1 (1.8)	1 (1.2)
Full-Time Carer	16 (1.5)	1 (1.8)	2 (2.4)
Ethnicity			
White	1044 (97.3)	55 (96.4)	84 (100.0)
Other *	29 (2.7)	2 (3.6)	0 (0.0)
Education			
University degree, Postgraduate degree	264 (24.6)	26 (45.6)	39 (46.4)
Further education, A/AS level, Diploma	349 (32.5)	20 (35.1)	27 (32.2)
Secondary School, GCSE	460 (42.9)	11 (19.3)	18 (21.4)

** Black African, Black Caribbean, Chinese, Indian, Pakistani, Asian other, Middle Eastern, Lebanese, Mexican, Half English*

Table 2: Pledges made by online participants in the 'Get a Better Life' campaign

Pledge		n (%)
Diet pledge	*Decreasing fat*	
	Eat one fewer high fat food item than I would normally eat each day	321 (29.9)
	Replace one high fat food item that I would normally eat with a lower fat option each day	162 (15.1)
	Eat one fewer takeaway meal than I would normally eat each week	46 (4.3)
	Increasing fruit and vegetable intake	
	Include a portion of fruit with one of my daily snacks	282 (26.2)
	Have a glass of fruit juice with breakfast	78 (7.3)
	Have an extra portion of vegetables with my evening meal each day	102 (9.5)
	None	1 (0.1)
	Other/own Diet Pledges	83 (7.7)
Physical activity pledge	Go for a brisk 10 minute walk in my lunch break daily	420 (39.1)
	Do one activity for at least 30 minutes with my family each weekend	420 (39.1)
	Get off the bus, one stop earlier when travelling to work	47 (4.4)
	None	2 (0.2)
	Other/own PA pledges	186 (17.3)

Table 3: Themes emerging from ‘reasons for pledges’ data

Theme	n (%)[a]
Health/fitness	776 (72.2)
Weight	480 (44.6)
Social factors	126 (11.8)
Diet	117 (10.9)
Physical Activity	105 (9.8)
Well-being	76 (7.0)
Other	16 (1.5)
Psychological	12 (1.2)

[a] *Total ‘reasons’ for pledges exceeds 1075, as some participants gave more than one reason for their pledges.*

Table 4: Diet outcomes for online participants with data at baseline and 6 months in the 'Get a Better Life' campaign

	Baseline		6 months	
	Mean (SD)	Median (range)	Mean (SD)	Median (range)
All participants (n=59)				
% Food energy from fat	31.9 (11.4)	32.9 (4.0-69.1)	28.8 (12.9)	32.4 (4.3-49.8)
Fruit and vegetable portions	2.7 (2.9)	2.0 (0.0-12.3)	2.6 (2.4)	2.0 (0.0-10.3)
Participants reporting on a 'normal' day (n=31)				
% Food energy from fat	33.3 (12.7)	34.83 (4.0-69.1)	27.3 (12.4)	29.2 (5.8-49.8)
Fruit and vegetable portions	3.1 (2.9)	2.0 (0.0-10)	2.6 (2.2)	2.0 (0.0-7.0)

Table 5: Diet outcomes for online participants with data at baseline and 12 months in the 'Get a Better Life' campaign

	Baseline		12 months	
	Mean (SD)	Median (range)	Mean (SD)	Median (range)
All participants (n=76)				
% Food energy from fat	31.05 (9.85)	32.40 (4.02-53.81)	30.8 (11.27)	29.86 (0.00-56.16)
Fruit and vegetable portions	3.03 (2.66)	2.54 (0-10)	3.09 (2.41)	3.00 (0-9.5)
Participants reporting on a 'normal' day (n=43)				
% Food energy from fat	31.6 (10.7)	31.5 (4.0-53.8)	29.0 (10.3)	29.2 (0.0-49.4)
Fruit and vegetable portions	3.3 (3.0)	3.0 (0-10)	3.4 (2.5)	3.0 (0.0-9.5)

Table 6: Physical activity outcomes for online participants with data at baseline and 6 months in the 'Get a Better Life' campaign

	Baseline		6 months	
	Mean (SD)	Median (range)	Mean (SD)	Median (range)
All (n=50)				
Mins MVPA	65.8 (174.7)	0.0 (0.0-925.0)	829.1 (1007.2)	517.5 (0.0-3955.0)
% ≥30mins MVPA	22.0		58.0	
Participants reporting on a 'normal' day and ≤480 mins MVPA (n=11)				
Mins MVPA	75.5 (131.4)	0.0 (0.0-325.0)	35.5 (117.6)	0.0 (0.0-390.0)

MVPA = Moderate to vigorous physical activity

Table 7: Physical activity outcomes for online participants with data at baseline and 12 months in the 'Get a Better Life' campaign

	Baseline		12 months	
	Mean (SD)	Median (range)	Mean (SD)	Median (range)
All (n=61)				
Mins MVPA	66.6 (152.7)	0.0 (0.0-630.0)	656.4 (913.6)	105.0 (0.0-4150.0)
% ≥30mins MVPA	22.9		55.7	
Participants reporting on a 'normal' day and ≤480 mins MVPA (n=13)				
Mins MVPA	16.9 (50.2)	16.92 (0.0-180.0)	17.31 (36.7)	17.31 (0.0-105.0)

MVPA = Moderate to vigorous physical activity

Table 8: Difference of means (bootstrapped 90% CI) of diet and physical activity outcomes between baseline and 6 months, and baseline and 12 months in the online 'Get a Better Life' campaign

	Difference of means (bootstrapped 90% CI) Baseline-6 months	Difference of means (bootstrapped 90% CI) Baseline-12 months
% Food energy from fat	-6.1 (-11.5 to -0.7)	-2.6 (-6.7 to 1.4)
Fruit and vegetable portions	-0.5 (-1.7 to 0.6)	-0.1 (-0.9 to 1.1)
Min MVPA	-40.0 (-145.0 to 71.0)	0.4 (-36.5 to 28.1)

MVPA = Moderate to vigorous physical activity

Table 9: Weight and BMI outcomes for online participants with data at baseline and 6 months in the 'Get a Better Life' campaign

	Baseline	6 months	
	Mean (SD)	Mean (SD)	Difference of means (95% CI)
Weight (kg)	81.8 (18.1)	81.8 (23.1)	0.0 (-4.2, 4.1)
BMI (kg/m^2)	29.0 (6.2)	28.9 (7.4)	-0.1 (-1.4, 1.2)

Table 10: Weight and BMI outcomes for online participants with data at baseline and 12 months in the 'Get a Better Life' campaign

	Baseline	12 months	
	Mean (SD)	Mean (SD)	Difference of means (95% CI)
Weight (kg)	80.3 (20.5)	80.9 (23.7)	0.7 (-2.7, 4.0)
BMI (kg/m^2)	28.1 (6.7)	28.2 (7.3)	0.1 (-0.9, 1.2)

Figures

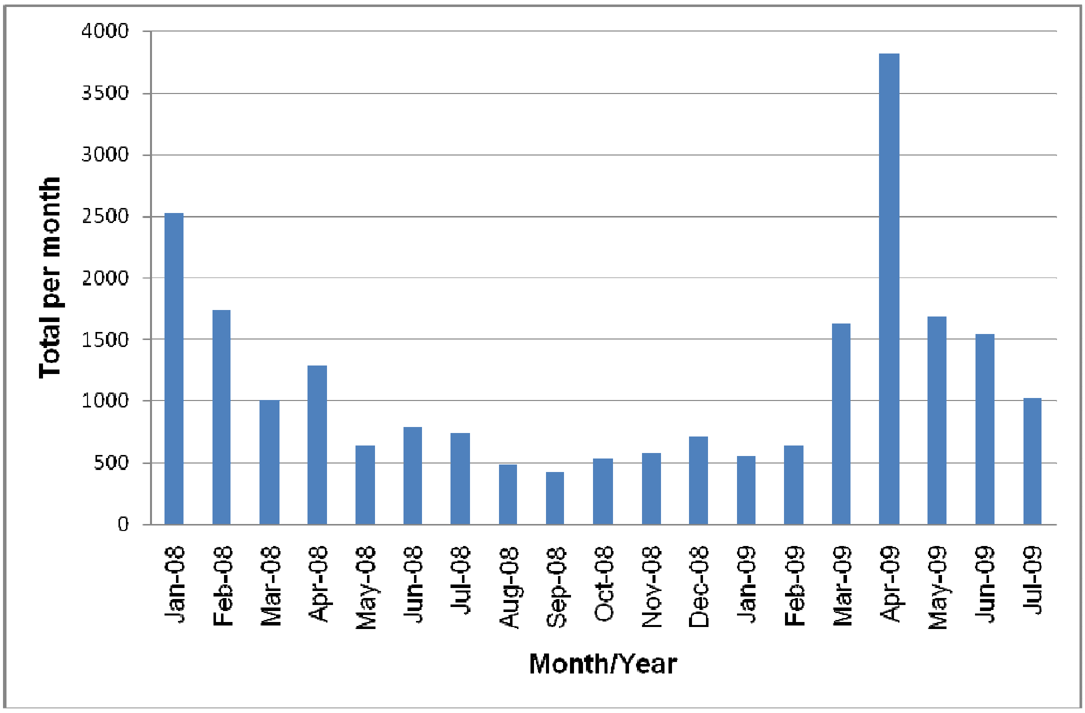

Figure 1: Number of visits to the 'Get a Better Life' website

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Appendix LL Draft paper on the impact of pledge making and perceived social support in the Get a Better Life campaign

The impact of 'pledge-making' and perceived social support for participants making and maintaining healthful behaviour changes: A theoretical thematic analysis

Catherine A Nixon[1], Frances C Hillier[1], Alan M Batterham[2], Alisha M Crayton[1], Claire L Pedley[1] and Carolyn D Summerbell[1]

[1]Obesity Related Behaviours Research Group, School of Medicine and Health, Durham University, Queen's Campus, Stockton-on-Tees, TS17 6BH, [2] Health and Social Care Institute, School of Health and Social Care, Teesside University, Middlesbrough, TS1 3BA

Abstract

This qualitative research explores the impact of behavioural contracting and perceived social support on participants' experiences of making and maintaining healthful behaviour changes. Twenty participants (12 female, 8 male) with a mean age of 53.2 years) from a community-based health initiative called the GABL campaign, took part in semi-structured interviews. Participants made 2 pledges: to make healthful dietary and physical activity behaviour changes over a 12 month period. Interview texts were explored using a theoretical thematic analysis procedure. Two key themes emerged from the analysis: (i) putting healthful behaviour changes into practice and (ii) maintaining motivation and change. Findings are placed within the context of social cognitive theory (Bandura, 1986), social support theory and research of behavioural contracting. The findings highlight the importance of appraisal support in participants' self-evaluation and self-regulation. The authors make recommendations for tailoring health behaviour change interventions to address individual support needs and suggest potential benefits to participants, of making behavioural contracts or pledges with a 'support buddy'.

Key words: behaviour change; social support; pledge-making; social cognitive theory; motivation

Introduction

Behavioural contracting and behaviour change

Health behaviour change interventions focus on increasing motivation to make and maintain new and healthier ways of living which may be particular to one's diet or level of physical activity in the management of weight or chronic diseases, such as diabetes and chronic heart disease (Beverly et al. 2008; Lasater et al. 1991; Steptoe et al. 2004; Williams et al. 2002). Behavioural contracting is an intervention used in the fields of education, mental and physical health services and by health professionals aiming to improve patient or participant adherence or compliance to health regimens or treatments (Neale, 1991; Ostfeld et al., 2007; Schlenk & Boehm, 1998; Wilson et al., 1990; Zandee, 1996). Known also as health or contingency contracting, behavioural contracting is underpinned by social cognitive theory (SCT) (Bandura, 1986), and while the theory as a whole is complex and predicts behaviour change as an interaction between personal, behavioural and environmental factors, self-efficacy and self-regulation are key cognitive capabilities underpinning the behaviour change strategy of behavioural contracting.

Behavioural contracting involves participants planning behaviour change goals, agreeing on specific changes they will make and identifying the consequences of maintaining change. A contract detailing the agreed changes to be made is then drawn up and signed by the participant. The contract is usually signed by a support person; either a health professional, family member or friend (e.g. Neale, 1991; Schlenk & Boehm, 1998). The act of signing a contract may indicate that a participant is motivated or 'ready' to make a change; conversely, the act may in itself increase participant motivation. Although we cannot know definitively the direction of effect, Neale (1991) suggests that "some combination of the two is probable" (p. 340). Motivation then, is a key psychological construct in adherence to behavioural contracts. In her review, Neale (1991) suggests that for family doctors and their patients "contracting can be a useful device for structuring behaviour change in motivated patients, but that without sustained contact with a health professional, such health behaviour improvements are not usually maintained over the long run" (p. 341). Not maintaining healthful behaviour changes may be the result of a number of factors, including lack of motivation, lack of perceived support and/or setting unrealistic goals.

In addition to motivation, behavioural contracting or 'pledge-making' - as it is referred to in the present study, is associated closely with the affective construct of accountability. It is suggested that developing and signing a behavioural contract generates a sense of responsibility within the participant and that failure to adhere to a contract can "induce guilt that participants have not only let themselves down, but also the person who co-signed the contract" (Haber, 2007, pp. 42-43). While motivation and accountability may be important psychological factors in adherence to behavioural contracts, it is also crucial that participants or patients are able to 'carry out' the agreed behavioural changes. Personal, social and environmental factors play a part in limiting and enabling individuals to put healthful behaviour changes into practice, depending on material circumstances, perceived support, experiences and beliefs. In this paper, we explore the interplay of pledge-making and social support in participants' health behaviour change experiences. It is appropriate at this point to explore theoretical constructs of social support in some detail.

Social support and behaviour change

The concept of social support in relation to health emerged from mental health literature, and was the catalyst for the growth of research interest in stress and psychosocial factors in the aetiology of health and illness (House et al., 1988). In recent decades, a positive relationship between social support and health has been acknowledged within health and psychological disciplines, highlighting consensus that low levels of social support are associated with poor mental and physical health.

Defining social support is notoriously problematic as various meanings, definitions and measures of support are forwarded. Despite this, Shumaker and Hill's (1991) review acknowledges some academic consensus on fundamental concepts of social support, where the difference between social networks (as relational structures) and social support (as a function of relations) is emphasised. Defining 'social networks' and 'social support' (Kelsey et al. 1996; Wallston et al., 1983) or the differences between 'structural support' and functional support' (Verheijden et al., 2005) is to highlight the difference between sources and forms of support. The benefits or otherwise of individuals' access to social networks and social supports is contingent on their *perception of* support (this is examined further below).

Social support is theorised from sociological, cognitive, interpersonal process and intervention traditions, as defined by Cohen, Underwood and Gottlieb (2000). Within the interpersonal process tradition, typologies of forms of social support were developed throughout the 1970's and 80's, from the categorization of 'informal helping behaviours' identified in various dyadic and group contexts (see Cohen et al. for a review of key research in this area). Work within this tradition "provides evidence that the materialization and benefits of social support are strongly influenced by many personal, relational, situational, and emotional characteristics of the interactional context" (p. 8).

As Hinson Langford et al. (1997) have identified, literature on social support in recent decades has focused in part, on the forms of support conceptualised by House (1981) including: (i) emotional support - the provision of empathy, caring, love and trust, (ii) instrumental support - the provision of tangible aids or services, (iii) informational support – the provision of information or advice that can be used for problem-solving and (iv) appraisal support – the provision of information that can be used for self-evaluation (or social comparison). For House (1981) social support is defined as "a flow of emotional concern, instrumental aid, information, and/or appraisal (information relevant to self evaluation) between people" (p. 26). A further form of support identified by Williams et al. (2002) is *autonomy support*, whereby significant others can "support individuals' autonomy (e.g., by offering choice, minimizing controls, or acknowledging feelings)" (p. 41). This concept of support is underpinned by self-determination theory (SDT) (Deci & Ryan, 1985) "which began as a theory of motivation and was then applied to the problem of changing health-relevant behaviours" (Williams et al., 2002, p. 41). We turn out attention now to examine the influence of social support on behaviour change, pertinent to the present inquiry.

Two key models of the influences of social support on health are the direct (or main) effect and stress-buffering models (see Cohen et al., 2000). While the latter suggests that social support prevents or reduces the negative health effects of stress responses, the direct effect model proposes that social relationships can have a direct impact on health as they shape health behaviours, psychological and biological states. More specifically, health promoting behaviours are shaped by social influences, services and information, and from the psychological states that ensue from their provision. What is pertinent here is the importance of *perceived* social support in healthful behaviour change. For Cohen et al. (2000) the association of perceived support with main effects on health "may be due to positive affective and cognitive states associated with the knowledge and security provided by the availability of others in times of need" (pp. 12-13).

Research suggests that behavioural contracting and social support can be effective in maintaining health behaviour changes. However, within recent studies, the impacts of social support and of behavioural contracting on health behaviour change outcomes are examined in isolation. Moreover, within this area of inquiry, links between behavioural contracting, perceived social support and maintaining behaviour change need to be more clearly identified. This paper aims to (i) explore the impact of perceived support on participants' experiences of taking part in a community-based health initiative, and (ii) consider the interplay between 'pledge-making' (or behavioural contracting) and social support in maintaining healthful behaviour change.

Method

Qualitative design

Semi-structured interviews were chosen as the qualitative method of data collection for this research inquiry to enable participants to reflect on and discuss their experiences of taking part in the Project. The GABL project was granted ethical approval by Teesside University's School of Health and Social Care Research Ethics Committee and Sunderland NHS Research ethics Committee.

Making pledges as part of a community-based health initiative (GABL campaign)

A key component of the GABL campaign initiative was 'pledge-making'; participants would pledge to make healthful changes to (i) their dietary behaviours and (ii) their physical activity behaviours. Adults in various local community settings (e.g. shopping malls, schools, community centres and health awareness events) were invited in person to take part in the face-to-face strand of the GABL campaign and made two pledges with a lifestyle helper. Online participants joined the campaign by registering on the GABL website and made two pledges. Pledge-making was participant driven; all participants were offered examples of dietary and physical activity related pledges, but were encouraged, if they preferred, to devise their own pledges (see Hillier et al., 2009 for further details of the campaign).

Recruitment of interviewees

Invitations to take part in an interview were sent to all participants from both strands of the campaign (n=1,201). Twenty participants agreed to take part in an interview and were contacted between May and September 2009 by the research team to arrange interview appointments at various locations; at The Life Store[1] (n=11), and at the interviewees home (n=2) or workplace (n=7).

All interviewees were living in Teesside, a conurbation in the North-East of England. In terms of health indicators, the North-East has the second highest regional prevalence of obesity in England for both men and women (North East Public Health Observatory, 2010). Participants took part in individual interviews (12 female, 8 male) and ages ranged from 35 to 68 (mean age 53.2 years). Interviewees' primary goals, and their diet and physical activity pledges are shown in Appendix 3.

Semi-structured interview schedules were developed in an attempt to draw out participants' personal experiences of taking part and were tailored to be 'strand' specific (see appendices 1 & 2). Having obtained informed consent from each participant, interviews were audio-recorded and transcribed verbatim by the first author. Although only one question was related specifically to issues of support, and one question on making pledges, participants did make reference to support issues and pledges made at various points during their interviews, when answering questions focused on other aspects of taking part.

Theoretical thematic analysis

Theoretical thematic analysis based on Braun & Clarke's (2006) framework describes analysis that is "driven by the researcher's theoretical or analytic interest in the area, and is thus more explicitly analyst-driven. This form of thematic analysis tends to provide less a rich description of the data overall, and more a detailed analysis of some

[1] The Life Store is an NHS venue within Middlesbrough town centre offering free advice and information on a wide range of health related issues and access to NHS and community-based health services (for further information visit http://www.lifestoremiddlesbrough.co.uk/)

aspect of the data" (p. 84). Original interviews with participants from the GABL campaign included broad questions about taking part in the campaign, and specific questions on support, motivations, barriers to change and making pledges. In this paper exploration of adults' social support needs in maintaining healthful behaviour is shaped by the analyst's knowledge of existing theories of social support and health behaviour change literature. Braun & Clarke's (2006) procedures for theoretical thematic analysis were followed to examine interview data specifically for participants' comments on, experiences of, and perceived needs for social support, and their experiences of making pledges.

It is acknowledged here that motivation to make healthful behaviour changes does not take place in a social vacuum; environmental and material influences are important factors in making and maintaining behaviour change. However, this paper focuses on individuals' perceived support needs and how their (un)met needs impact on motivation to make and maintain healthful changes. This research takes a realist epistemological position in terms of the analysis of meaning, where analytic interest is in participants' motivations and individual psychologies; meaning and experience is reflected in language (Braun & Clarke, 2006) in contrast to the social construction of narrative accounts. While taking a semantic approach in the present thematic analysis, that is, "themes are identified within the explicit or surface meanings of the data" (Braun & Clarke, 2006), analysis moves beyond description, to the interpretation and theorisation of thematic configurations identified.

Interview recordings were transcribed verbatim by two researchers (the first author made checks for accuracy between transcripts and recordings, and made subsequent corrections as required). To become familiar with the data, all transcripts were read for the first time without coding. At the second reading, sections of data pertaining to social support and pledge-making were highlighted manually and points of interest were also noted by hand. Although coding was directed by existing literature and typologies of social support, themes identified outside of existing work were also highlighted for further investigation.

Results

Thematic analysis

In engaging with interview data and drawing on existing theories of social support and behaviour change, a comprehensive and iterative thematic analysis procedure led to the production of two key themes in relation to pledge-making, social support and health behaviour changes: (i) Putting dietary and physical activity changes into practice and (ii) Maintaining motivation and change.

(i) *Putting healthful behaviour changes into practice*

Dietary behaviour changes

As discussed earlier, participants made one of 2 dietary pledges; to increase fruit and vegetables or to reduce fat in the diet. Some participants made dietary pledges which combined both of these behaviours. When discussing dietary behaviour change, interviewees made reference to family members as important sources of support; a lack of familial support was also emphasised by interviewees who lived alone. Research on relationships between social support and gender suggests that traditionally women provide care for family members including their children, husbands and often elderly parents. Findings from the present research suggest that making dietary changes appeared more difficult for women than for men, and support Kelsey et al's (1996) suggestion that "men may be accustomed to receiving help from their wives in the areas of health and food management" (p. 392). Colin and Simon did not perceive barriers to making dietary change; the procurement and preparation of healthy food, was planned and carried out by their wife:

> *I think we are eating more veg and fresh veg and stuff like that so… my wife's always been, good that way […] and we've cut back on like ready-meals […] my wife's been encouraging you know* (Simon, 57)
>
> *I discussed with my wife, (about eating) a bit more fruit so we thought 'oh well, have a bit of fruit at breakfast time' the rest of the fruit, well at lunchtime and the evening meal, that just happens and there's always a bowl of grapes in the kitchen. So every time I go into the kitchen I help myself to a grape or two […] on the one hand I could say 'yes, just part of my normal day' on the other hand my wife is very supportive, she is very much into health so she makes sure there are lots of vegetables at the evening meal and there's plenty of fruit around, as you can see* (Colin, 67)

Most meals are prepared within the home and shared between family members; agreement between family members on food choices, methods of cooking, portion sizes, and willingness to try new foods will be perceived as supportive to individuals making healthful dietary changes. Fiona spoke positively about the way her husband had embraced new ways of eating healthily since she had joined the GABL campaign:

> *We [Fiona and her husband] never used to buy (unfamiliar fruit and vegetables), because, I mean I do the shopping […] we've got a list on the fridge of all fruit and vegetables we've not tried and I've not used, we're down to the last two or three now, I think we've got aubergine left to do […] We went round Morrison's and Tesco's and just wrote down this massive list because you don't even notice them unless you're looking for them […] and we wandered around, I mean I'd heard of courgettes but I'd never seen them tiny small ones that you can cook whole, so there was loads of different things so we went round and wrote a list and then we've just been working our way through* (Fiona, 38)

In addition to emotional and instrumental forms of support from family members regarding dietary change, support from family members was also given in the form of advice that was used by participants to make healthful changes. Research does emphasise the importance of informational support as part of a problem-solving process (see Hinson Langford et al. 1997) and the utility of informational support in making and maintaining dietary changes was evident within several narratives:

> *I had a problem with sore joints and my wife said 'oh, you're taking a particular type of pill which will probably reduce the potassium level in your blood, have a banana every day* (Colin, 67)
>
> *I'm really taking notice of me daughter who is fairly fit and a runner, so I have listened to her you know, so I will make a rule of (cutting) the plate size down and eat smaller meals and more often* (Pauline, 68)

The majority of women in this research (11 out of 12) were responsible for food shopping and preparing meals, either for themselves alone or for their family and for women more than men, dietary pledges were more difficult to make and maintain than were physical activity pledges. The convenience or temptation of eating meals prepared for other family members were emphasised; time constraints and the inconvenience of preparing meals for oneself and something different for the family were also highlighted. Furthermore, given women's traditional role within the home, Kelsey et al.

(1996) suggest that "family members may not perceive that women can use help in trying to make dietary changes" (p. 392).

> *(With John) working shifts, he doesn't get in maybe till half past seven, I finish work at quarter past three, the kids come in at half past three type of thing so it's getting away from that 'right we'll have a snack till Dad comes in' or 'do I cook the meal and we have ours all together at five and John has a warm up later on' or, because I'm a finicky eater, I know I am but the others aren't. So it's you know, well I'll cook a meal for John and (the children) will have something different, I'll have something different [...] but it's just being organised to do it* (Wendy, 46)
> *It's when I'm cooking, if the family (are) coming over for dinner (and I'm) trying out new recipes i.e with cake or cheesecake and once I'd cottoned on how to do a no bake cheesecake, it's, of course it's double cream and mascarpone and if I don't freeze it (or) give it to them to take home, I tend to mop up...*(Rita, 66)

Relevant to exploring the practicalities and implementation of dietary changes, research suggests that in contrast to the difficulties of planning meals and meal-times around the family, older adults often have difficulty maintaining a healthy diet when living alone (Gustafsson & Sidenvall, 2002), a problem exacerbated by low income (Lyon & Colquhoun, 1999). Penny lived alone and had made a pledge to increase her fruit and vegetable intake with the goal of achieving a healthy lifestyle. Despite increasing costs of fruit and vegetables locally, and the difficulties of preparing meals "when you've only got yourself to cook for", the perceived emotional and informational support that Penny received from the GABL team was helping her to make and maintain healthful dietary changes:

> *I think knowing someone else was there for me [...] you know if I'd have done it on my own I'd have given up probably [...] you (the GABL team) were interested as well as me; you know, you wanted me to do it for myself* (CN: so that gives you a bit of an incentive?) *yeah 'cos there's someone else to do it (for), but I think if you're doing it for yourself you think 'oh well, you know I'll have a bar of chocolate, it doesn't really matter' but then when someone else .. I suppose it's the same as having a partner really. You know, they say 'well don't eat that, it's not good for you' but when you're on your own, no one to tell you that [...] I haven't had any support other than you so that's why I thought that was so important [...] it was like family support because you did keep in contact and*

you sent the letters out with… you know what's in season and recipes and stuff (Penny, 57)

Motivation to make and maintain dietary pledges was shaped by interviewees' perceived social support. Research of health behaviour interventions targeting dietary change highlights the importance of family members in their role as support person (Beverly et al. 2008; Powers et al. 2008). Penny described the GABL team as supportive; the excerpts above emphasise the (mainly) emotional support that Penny derived from the GABL team. Cohen et al. (2000) highlight the association of perceived support with health promoting behaviours, and it is suggested here that interviewees' knowledge and perception of support (in its various forms and from a variety of sources) helped them to stay motivated and maintain dietary changes. Conversely, a perceived lack of support can lead to negative cognitive states and reduction in motivation to make and maintain healthful changes.

Physical activity behaviour changes

Many interviewees in the present study spoke of increasing their physical activity levels, with reference to social networks and often, particular people and groups who were involved with them in their exercise regimes. In Thomas et al's (2009) research, participants expressed a preference for a variety of characteristics that a support person would possess. In addition to empathy and positive reinforcement, participants highlighted "being committed to working together with them to increase physical activity" (p. 347) as an important characteristic. In the present analysis, various sources and forms of social support were identified in relation to participants' initial implementation of physical activity behaviour changes. In addition to the utility of social support in implementing new exercise regimens, participants also developed new social networks and further sources and forms of support as a consequence of 'getting started'. In the excerpts from an interview with Chris (see below), instrumental and emotional support came from a number of sources: his manager at work, friends and family.

"I've joined the gym on site, so I go to a gym on site, on a lunch time, and the boss gives us an extra fifteen minutes really because, like to do it in your hour, by the time you go across there (to the gym) drive across get changed and stuff,

you only have twenty minutes on a treadmill or something but I suppose that's better than just sat at my desk anyway…

"Because I've been going to the gym (at work), I met some guys that play football up at (a local) football club, which I love football […] we now play football on a Saturday and on a Friday here, so I suppose finding that time to do something's led to more time if you know what I mean?

"Not only have I joined the gym there (at work) I've joined Total Fitness (locally) with my wife and two kids, […] Total Fitness is the only gym where they've got like a little kids gym-thing so, between five and seven… on a night, you can go and they can go there […] so we joined there, paid up front for the year and said right 'we have to go'… so I suppose it's led to family time as well" (Chris, 35)

For some interviewees who had pledged to increase their levels of physical activity, having 'friendly competition' was perceived as motivating and came from friends, colleagues and family members who were trying to achieve similar goals:

"I think we all wore our pedometers for the first two or three months because we had a little competition between us, we were clocking up steps and I found myself making excuses to go down the corridor 'cos the kitchen staff were beating me!" (Fiona, 38)

My sister was saying 'well I could do with losing a bit of weight as well' […] so we went walking, and we were pushing the (children's) buggies, and er…then we'd start going a little bit ***further*** *each journey, further until it came to the point where we were doing about 5 miles in a day, and then like when her husband was off work we'd say like 'leave the kids with him, and we'll go for a run', and then we'd start with a bit of jogging, and of course you're out of breath when you first start doing it, but gradually over time we were building it up and we were like 'ee we're not as out of breath now' and we were going a bit further, and it's like pushing yourself, and like I say, your competing against* ***each other****, not in a nasty way, in a friendly way, it's like we'd say 'lets see how much further we can go' and it* ***does*** *give you the incentive, to go on* (Sally, 41)

Many of the women in Thomas et al's (2009) study reported a preference for tangible support (such as having someone to work-out with). Lisa, who was unemployed and spending much of her time at home job-searching online, describes how family members support each other in their aims to increase their physical activity levels:

> *It's a case of basically being bullied into doing things! 'What have you done today? Let's get you out'... you know with being stuck in a house all day, 'you've been looking for jobs, let's go for a walk' that sort of thing [...] 'cos me mum's trying to increase her activity as well [...] she's got bronchitis so exercise for her is out really, it's really bad, it's chronic and just gentle walking and building it up to a faster and faster pace has been helping; she can keep up with me, and I get slightly out of breath so that's great for her and then it's just a case of building on that exercise, (we) help each other* (Lisa, 42)

Alan described what had motivated him to maintain physical activity changes in the past. Alan's comments, even in this relatively informal example, highlight the motivational component of accountability identified in research of 'behavioural contracting' (Haber, 2007):

> *I know about three years ago I joined the gym, and I joined it with a friend of mine, and I must admit that to have someone to go with to exercise with, it does, motivate you because some days, you don't feel like doing it, other days you do and they don't and so…but because there's someone going you know you feel that you should… and I went probably, well we used the entire years membership after that…so it does work the sort of buddy system I think* (Alan, 48)

Involvement in health groups, health initiatives and community-based health interventions can be a motivating factor for many people trying to make health behaviour changes. Groups and interventions may provide members and participants with access to new social networks and a combination of various forms of social support. As individuals' perceived support needs are different, so are the kinds of interventions or programmes they are motivated (or able) to take part in:

> *"(A local cycling group is held) every two weeks and it's a ten mile cycle ride, or roundabout that, and you all meet together and we went round (local town) which is great 'cos you see the parts that you don't normally see **and** you're with other people so you feel protected [...] (after seeing the GABL campaign in the Gazette) I thought 'right that's it, I must do something' and that did kick start me into thinking, right I've got to start doing a little bit more exercise*

rather than just sitting and doing nothing [...] I quite enjoy the groups that I've been going to, because it's social as well as everything else. You can have a laugh while you're exercising, you know, which makes it- you know, you imagine all of these fit athletes going on a course and thinking 'oh well, God I'll be the oldest and the worst' but (CN: so it's not like that) it's not at all no" (Linda, 54)

Bill reflects on his involvement in a local men-only weight-loss group during the past year; in emphasising the positive impact this has had on his goal to lose weight, Bill highlights the benefits of emotional support from 'like-minded' others who have similar behaviour change goals:

I (joined) the men-only Slimming World group (locally) which has been hugely successful...I've lost three stone in a year [...] I've lost it over quite a lengthy period, and I'm with a gang of guys that are all trying to do the same thing, there's not the embarrassment factor, we have a laugh (Bill, 47)

Many of the women in Thomas et al's (2009) study reported "a lack of support for weight loss among their family and friends" (p. 346). It was evident throughout the analysis that a majority of women interviewed experienced barriers to making healthful changes. There were often contradictions within their narratives regarding support from family members; for example Wendy and Rita talked about how family members laughed at the pledges they had made but they also expressed that their family was supportive of their behaviour change goals. Although Wendy appears to have instrumental supports enabling her to attend local leisure facilities, emotional supports from her family are less well defined. The differences between structural and functional support (Verheijden et al., 2005) is pertinent here; "structural and functional support is not necessarily highly correlated" (p. 180).

"(My children) just laugh at me [...] well they don't, no, I mean they enjoy going out, you know like when we're going to the table tennis and stuff but yes you know they think it's a good laugh that Mum's having a go at doing it (CN: and did you need their support whilst taking part in the campaign?) *no because I think I wanted to do, I knew I wanted to do it myself anyway so I would have done it, no matter what they say"* (Wendy, 46)

For Pauline, who had fallen several times in recent years, was not confident about walking alone and she was uncertain about where or from whom support might come:

> *"If I'd had that little bit more organisation within myself, you know, I might have been able to have stuck, you know, stuck to the planned walking, you know with somebody else, but I haven't got anybody to go with me and I am a little nervous because of falling you know I've fallen a few times and I'm a little nervous […] I would have liked to join in the walks (at the Life Store) but circumstances hasn't permitted me"* (Pauline, 68)

In this section we have explored various forms and sources of social support and the ways in which perceptions of support enabled or constrained participants' actions and ability to put change into practice. In the next section we focus on ways in which processes of social support and pledge-making or behavioural contracting impact on participants' motivation and how motivation and change were maintained (or not) throughout their involvement in the campaign.

(ii) *Maintaining motivation and change*

For a number of participants, emotional support from the GABL team was highlighted as an important motivating factor (see section i). Earlier we highlighted how Penny was motivated by her perception of 'family support' or emotional support from the GABL team; she felt psychologically supported by the teams' interest in her wellbeing. Also relevant to the concept of emotional support is accountability; an affective construct associated with behavioural contracting (Haber, 2007) that was expressed by several interviewees as a feeling of responsibility to the GABL team; that in failing to maintain their healthful behaviours they would be letting the team down:

> *Well I suppose there is a challenge, and I know that you're coming to talk to me so I've got to make sure that I continue with eating lots of fruit and being out and about on my bicycle and swimming so well I suppose .. swimming every Tuesday and going to the gym Thursday or Friday is fairly standard but it's something that I've got to keep going at (CN: Right and is that because of the campaign or is it just because of you?) Mainly me, but I don't want to admit to you that I've given up the gym* (Colin, 67)

Coming down (to the Life Store) and talking about it, helps, because otherwise if you go home, you do things and you think 'oh I'm not bothered no more' don't yer? …you just put it to one side and don't bother. But because I knew I was coming back I stuck to it, you know and I think that helps […] you know that you've got to be good because you're going back to see someone…keeps you on the straight and narrow! (Barbara, 67)

Diet and physical activity information and resources that the GABL team provided, both online and in newsletters posted to community participants, were perceived positively by several interviewees. It was evident that newsletters including recipes and tips on diet, and information on family, leisure and sports activities taking place locally, were useful motivators for those involved. For many interviewees, informational and appraisal supports were central to self-regulation processes, continued motivation and adherence to pledges made. For some interviewees, the opportunity for self-evaluation on their progress came from friends or family members who were also involved in making healthful changes, often described in terms of 'friendly competition' (see section i). Several interviewees described ways in which they were able to evaluate their progress, where general diet and physical activity information or personal feedback on measurements were perceived as motivating factors in the process of self-regulation:

The best thing about taking part is, for me it's all the little tips that you get on there (website) of what are the things best to eat or what's the best thing in exercise, twenty minutes of exercise a day can lead to- like this sort of stuff, yeah little facts and figures, because it's stuff, I don't sort of realise I suppose (Chris, 35)

I seem to remember that it (the GABL website) suggested small things that were achievable rather than rushing out and buying a very expensive gym membership…you know, why not try walking that bit further or having that extra piece of fruit a day or whatever (Alan, 48)

The information (has been the best thing about taking part); the information that I got from you (weight and diet related information), I intend to get it all together and any other information that I have and the books, and keep it all together and go through it all, so I'll get an idea about what I've done and what I shouldn't have done (Pauline, 68)

Pauline's comment (above) also highlights the importance of self-evaluation against social behavioural norms. It is possible to identify mechanisms of self-efficacy and self-regulation as part of the behaviour change processes within interview narratives. One element of self-efficacy that emerged from the analysis was interviewees' social comparison of personal performance to the performance of others (Bandura, 1986). Social cognitive theory suggests that this kind of social comparison influences an individual's self-regulation behaviours; that is, evaluating one's own performance or indicators of success can lead to self-directed changes within an individual. Although this is a simplified account of a complex process in which a number of personal, environmental and social factors are involved, such mechanisms emerged as significant in the present analysis. The utility of receiving feedback on performance was highlighted by a majority of interviewees, highlighting the salience of appraisal support in participants' self-regulation. Elements of social comparison and self-evaluation processes are evident within the excerpts below.

> *(Data collection appointments) gave me a point where I could say, ok, let's re-evaluate…what have I done, what haven't I done, what's not working, what can I try?...so it gave me a point (where) I could just re-evaluate what I was doing* (Lisa, 42)
>
> *(Feedback online) gave you an opportunity to look at what you were doing now as against what- 'coz I kept the (Snapa™ information) on my computer that I'd filled in originally, and looked at- when you're asked you know what you were having for your breakfast and lunch and what activities you were doing, you were involved in, I kept all the original ones and just kind of compared the two, which was quite useful as well…it kind of quantified where I'd been a year ago, to where I was now, which is totally different* (Bill, 47)
>
> *The best thing (about taking part in GABL) would be the motivation it gave me. It did actually give me motivation to do something but maybe on my own I might have been saying 'oh I'm not that fat' because everyone was saying like 'you're not fat' but when I got on the scales it was a different matter* (Lisa, 42)

The need for appraisal support from health professionals over and above other sources of support highlights the unique role that health professionals have in providing valid and *valued* feedback on progress. Feedback and appraisal support from the GABL team (face-to-face and online) was important in its impact on motivational processes and maintaining behaviour change. Fiona and Alison highlighted how more regular support from the GABL team would have helped them to maintain their motivation. It is clear that feedback and appraisal support were important perceived support needs:

> *I think, yeah it would have been better if it (data collection appointment) was monthly, not only for recording but I think that would have given us more of, you know if we were aware of recorded weights, I think if it was done monthly it would have motivated us more to take it a bit more seriously rather than it being six monthly and we got to half way through and then it was like, you'd forgotten about it until you got the letter that told that you were coming […] So I think if it was monthly it would motivate you to stick to it more and it would motivate you to look because we all want good results […] and I think we would have put more of a commitment in to getting a better result if we knew we were being checked every month […] it's a bit like the slimming world thing isn't it? - if you know you're going to be weighed every week, you don't like that embarrassment of standing on the scales and finding out you haven't lost* (Fiona, 38)
>
> *I think, what would have helped me is if I'd had the weigh-in…rather than at 6 months, if I'd have had it earlier, and been sort of measured up and [told] 'well you haven't lost anything', it would have spurred me on earlier than at 6 months …because it would have made me think 'oh, I'm not doing this right'* (Sally, 41)

The difficulties of maintaining motivation when motivators are extrinsic, highlights the utility of pledge-making long-term and the perceived need for more regular appraisal support. Alison (see below) highlighted the difficulty of maintaining motivation at the beginning of the campaign.

> *We did try and- at work we got a pair of scales and tried to like do it- like three of us, but then Jill went on the sick, and Kelly went off her diet, and then I lost my motivation then… coz I was on my own… Sue bought the scales and never came in (to work) to get weighed…and I just sort of gave up from there- but, after that me and Jill went to Slimming World and did it 'till Christmas and then gave up…* (Alison, 42)

The practice of 'pledge-making' was discussed by several interviewees as a positive and useful part of their participation in the GABL campaign. The processes involved in 'pledge-making' or behavioural contracting resonate with those in goal-setting (e.g. Anderson et al. 1998; Orbell et al. 1997) where specific, measurable goals are created. For Nothwehr & Yang (2007) "frequent goal setting that is focused specifically on diet or physical activity was more predictive of using dietary or physical activity strategies, respectively, than goal setting focused on weight loss overall" (p. 532). Similarly, Bill's comments emphasise the importance of making behaviour change goals *specific* as part of the pledge-making process, rather than general:

> *(Making the pledges) made you think about doing them, rather than saying 'I want to lose weight' with that (the pledge idea) I'd say 'I want to eat more fresh fruit and veg' and I did, it was very specific, it was kind of SMART as they say, measurable, and I could see, was I doing it or wasn't I? And if I did do it was I gaining any success from it? Which I* ***was****…so then the exercise thing kicked in and you start thinking 'well I made some pledges about getting a bit more active', can I get a little bit* ***more*** *active…?* (Bill, 47)

Early in the campaign Alison had experienced a lack of support from friends and colleagues in their joint effort to lose weight. Alison did, however, emphasise the long-term benefits of 'pledge-making' in addition to her perceived need for more regular appraisal support; feedback that would have enabled her to evaluate her progress.

> *I think that making the pledge is good…and eventually it did sort of…you know it must have been stuck there at some point, and then I eventually (made changes), but I think if I'd had some type of support that was regular and that was sort of more, I don't know…just regular and something that I could log and keep a tally of, something I could sort of look and think this is what I've done, I probably would've (made changes) sooner* (Alison, 42)

Discussion

Key themes emerging from this theoretical thematic analysis were (i) putting healthful behaviour changes into practice and (ii) maintaining motivation and change. Our findings presented in the first section of this paper, highlighted the importance of participants' perceived social support from family, friends, colleagues and health professionals, in implementing healthful changes in their daily lives. It was evident from this analysis that for participants making dietary behaviour changes, family members were important sources of social support. The planning, procurement and preparation of food were important practical steps in making dietary changes; the ease or difficulty of negotiating food preparation, was shaped by participants' perception of (predominantly) emotional and instrumental support (House, 1981). Supporting previous research, the findings from this analysis suggest that making dietary changes was more difficult for women than for men (Kelsey et al. 1996), highlighting the difficulties of planning and making dietary changes for oneself and preparing different meals (sometimes at different times) for other family members. A majority of interviewees making dietary changes reported feeling supported by family members and that this support was important. For interviewees who lived alone, problems of food wastage (food going out of date before it can be used), the effort involved in cooking a healthy meal for one, lack of appetite, comfort-eating and unhealthy snacking etc. were perceived as barriers to making healthful dietary changes. Some of the aforementioned barriers were not exclusive to those participants living alone; many interviewees commented on the difficulties of maintaining motivation to make dietary changes (we discuss maintaining motivation later in this section).

A majority of interviewees had made pledges to increase their levels of physical activity on a daily or weekly basis (an exception to this was Colin who had pledged to maintain an already busy schedule of physical activities). The experiences and individual support needs of interviewees in this research highlight how social networks and social support are inextricably linked. This was particularly salient when interviewees talked about increasing their physical activity levels; for many, existing social networks, including family members, friends and/or colleagues were perceived as supportive. Thomas et al (2009) identified that it was important to participants in their research that a support person would *work with them* in achieving their behaviour change goals. Similarly, in the present analysis, a number of participants talked about the perceived benefits of taking part in physical activities, such as attending a gym, swimming, running etc. with a friend or family member. Interviewees identified emotional support from family members and friends as 'friendly competition' or 'encouragement'. Furthermore, the provision of support in these situations was not one-way; interviewees also spoke about feelings of responsibility; of not letting their partner down (the affective construct of accountability is further discussed below).

Leaders and members of commercial weight loss groups such as Slimming World, and sports or leisure facilities such as gyms and exercise groups (and to some extent the GABL campaign team) were also emphasised by several interviewees as important sources of social support. Although these may be viewed as formal supports, it was evident that such sources of support also led participants to new social networks and for some, new sources of support. It was clear that participants in this inquiry felt motivated by their involvement within the GABL campaign, by their perception of social support and by the pledge-making process. From a social-cognitive perspective "perceived support promotes self-esteem, which leads to health outcomes" (Lakey & Cohen, 2000, p. 37). It is also generally understood that support is not a stand-alone predictor of healthful behaviour change; psychological factors such as motivation and self-efficacy are also key in achieving behaviour change goals.

The impact of appraisal support on participants' self-regulation and motivation was a salient finding in this inquiry. It is suggested that feedback on progress provided by the GABL team (and to a lesser extent family and friends) enabled participants to evaluate their performance (against social norms) and use this information to regulate their behaviours. This further supports Lakey & Cohen's (2000) research claim of a strong association between perceived support and self-evaluation. The authors suggest that appraisal support (information on health behaviours and personal feedback on measurements) from the GABL team was germane to the process of self-evaluation and self-regulation for participants in this inquiry.

Interviewees spoke about their pledges in general and about specific behaviour changes they had made; not in an asocial (pledge-only driven) context but with reference to other people who supported them in making and maintaining their behaviour changes. Making pledges was referred to by a number of interviewees as motivational, although the execution of behaviour changes was socially influenced. Research does suggest that enhanced motivation to make healthful changes is mediated by processes of behavioural contracting and by social support. In Neale's (1991) study, behavioural contract signers "stated that the signing of the contract with its explicit goals enhanced their motivation to improve their health risk profile" (p.341). Participants taking part within the GABL campaign made two pledges to change their diet and physical activity levels and on this basis, could be deemed to be highly motivated to make healthful changes. Furthermore, based on direct models of social support "[s]ocial support may trigger behaviour change by providing information about diet or exercise, by providing reassurance, or by increasing compliance to treatment" (Verheijden et al. 2005, p. 180). While pledge-making appears to increase motivation, we must acknowledge the role of social support in maintaining change on a day-to-day basis and acknowledge the interplay of support and pledge-making processes in maintaining motivation.

Social support was not a formal intervention in the present study, although it is hoped that interviewees' comments on perceived support and support needs from various sources will be useful in informing future community-based health initiatives. Tilden & Gaylen (1987) raise the point that social relationships are predominantly viewed as positive and that it is important to acknowledge potentially negative social relationships. This is evident in research that highlights the impact of what has been termed 'negative support' where friends or family members hold negative attitudes about change and sabotage healthful behaviour change efforts (Kelsey et al. 1996). It was evident that for some interviewees in the present study, people, in addition to environmental and material constraints, often presented barriers to change. As various forms and sources of social support were perceived as beneficial by interviewees it is clear that provision of social support as an intervention tool needs to be tailored to the individual participant or patient; Verheijden, et al (2005) comment on the limited use of tailoring in their review of social support interventions. Furthermore, the authors suggest that participants with limited social support networks may benefit from the provision of support from health professionals as a *stepping stone* (as opposed to an alternative) to developing social support and friendship networks.

While behavioural contracting is underpinned by social cognitive theory (Bandura, 1981) and specifically processes of self-regulation and self-esteem, the complex interplay of personal, social and environmental determinants on motivation and behaviour change is also acknowledged. Therefore, although behavioural contracting may be a useful tool in health change interventions, psychological barriers and material constraints in making and maintaining change must also be considered. Lasater et al's. (1991) research on participant weight-loss in a community-based intervention highlights that successful weight-loss was "evident by continued availability of the program and the increasing number of new participants 'referred' to the weigh-in by members" (p. 175). The GABL campaign came to an end after 12 months; this was disappointing for many interviewees who commented on ways in which participation helped them to maintain motivation. However, the amount of contact that health professionals can realistically provide to individual patients or participants is limited and this must always be accounted for in planning community-based interventions: training 'community champions' or key community leaders to provide continued support within a community is one of several alternatives forwarded.

Behavioural contracting or pledge-making in this research was not a formal or primary intervention tool. However, as all campaign participants made two pledges voluntarily, the impact of this element of participation was worthy of further examination. It is also important to highlight here that 'community' strand and 'online' strand participants made their pledges in different social and environmental contexts. These differences, that is, face-to-face and virtual pledging will shape (in part) the subjective experience of behavioural contracting. It is suggested that the processes of behavioural contracting can generate feelings of responsibility or accountability within the participant or patient (Haber, 2007). Although the impact of 'face-to-face' pledge-making vis-à-vis 'online' pledge-making was not assessed here in primary outcome measures, it is possible that 'community' strand participants' felt more accountable than did the 'online' strand participants, to the GABL team member with whom they made their pledges. It is evident that further investigation of the impact of virtual or online pledging is needed to explore affective processes and commitment to change.

It is evident from this analysis that pledge-making or behavioural contracting is a useful health intervention strategy. We suggest that behavioural contracting as an intervention will be more successful in its aim, if the *perceived* support needs of the participant are explored and that interventions are tailored to meet individual needs. While pledge-making might generate feelings of responsibility and motivation to change, it is important that participants have the 'right' social supports in place to enable them to execute their desired health behaviour changes. Moreover, it may be more useful for participants to make a behaviour-change pledge with someone who will support them emotionally and practically; who will help them to actualise specific behaviour changes, for example, by going running together, or by providing transport to leisure facilities. Behavioural contracts could be made between participants or 'support buddies' to form a partnership of mutual accountability.

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